JT9D-7R4

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POWER PLANT

Overall System Data

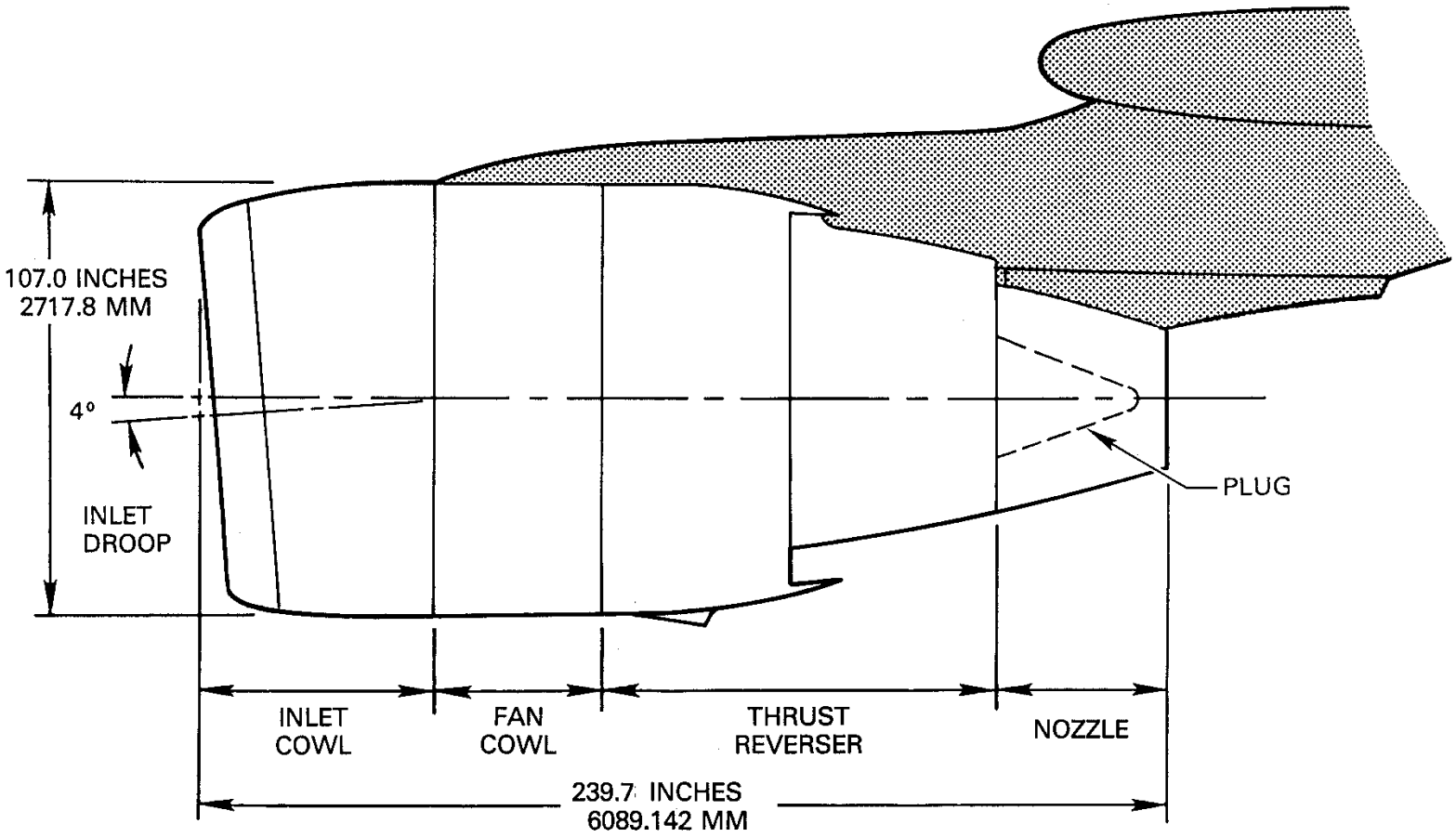
Purpose:

- The power plant supplies the thrust to power A310 and A300-600 aircraft.

Description and Operation:

- Nacelle components:
  - Inlet cowl
  - Fan cowl
  - Thrust Reverser
  - Nozzle
  - Plug
- Engine dimensions:
  - Major diameter: 107 inches (2717.8 mm)
  - Length: 239.7 inches (6089.142 mm)
  - Inlet droop: 4 degrees
- Weight (approximate):
  - Engine: 8,915 lbs.
  - Nacelle and Engine Build Units (EBU): 3,438 lbs.
  - Total installed weight: 12,353 lbs.

Power Plant Pressurized Nacelle



CT4011.19970924

CT4011

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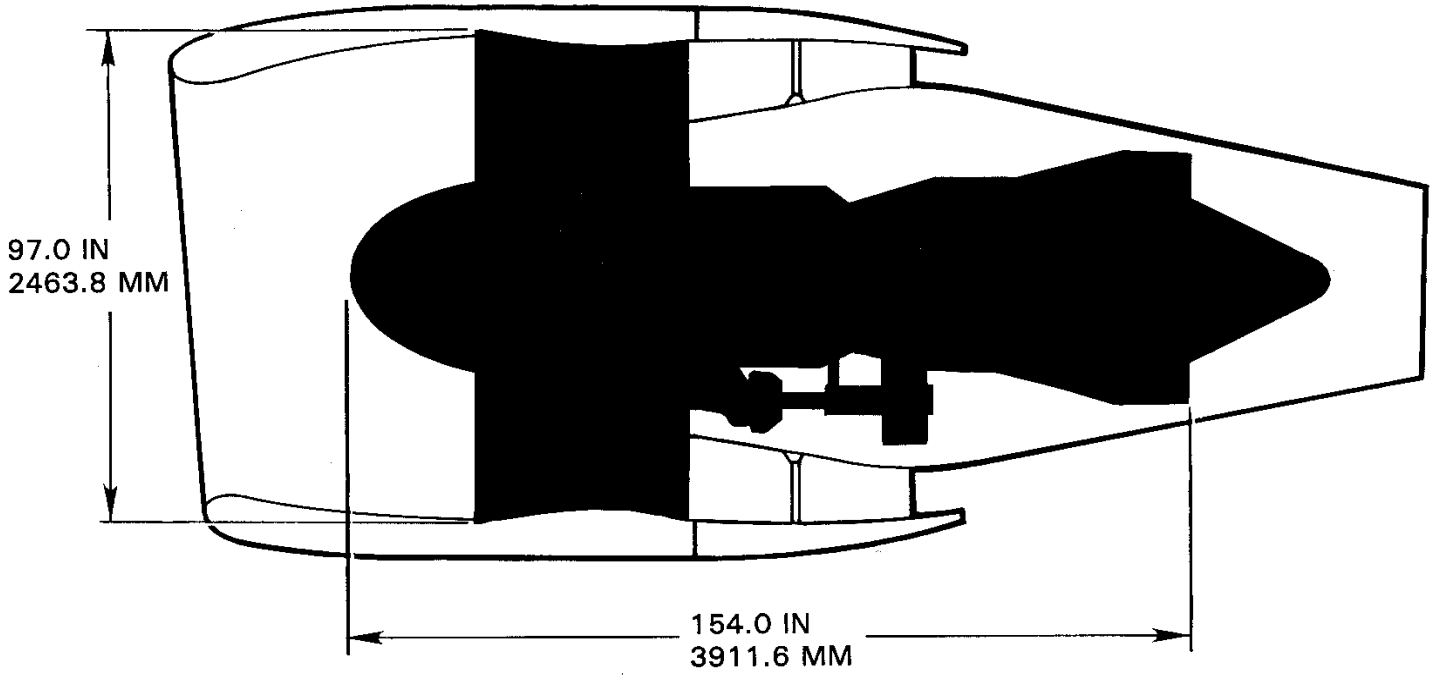
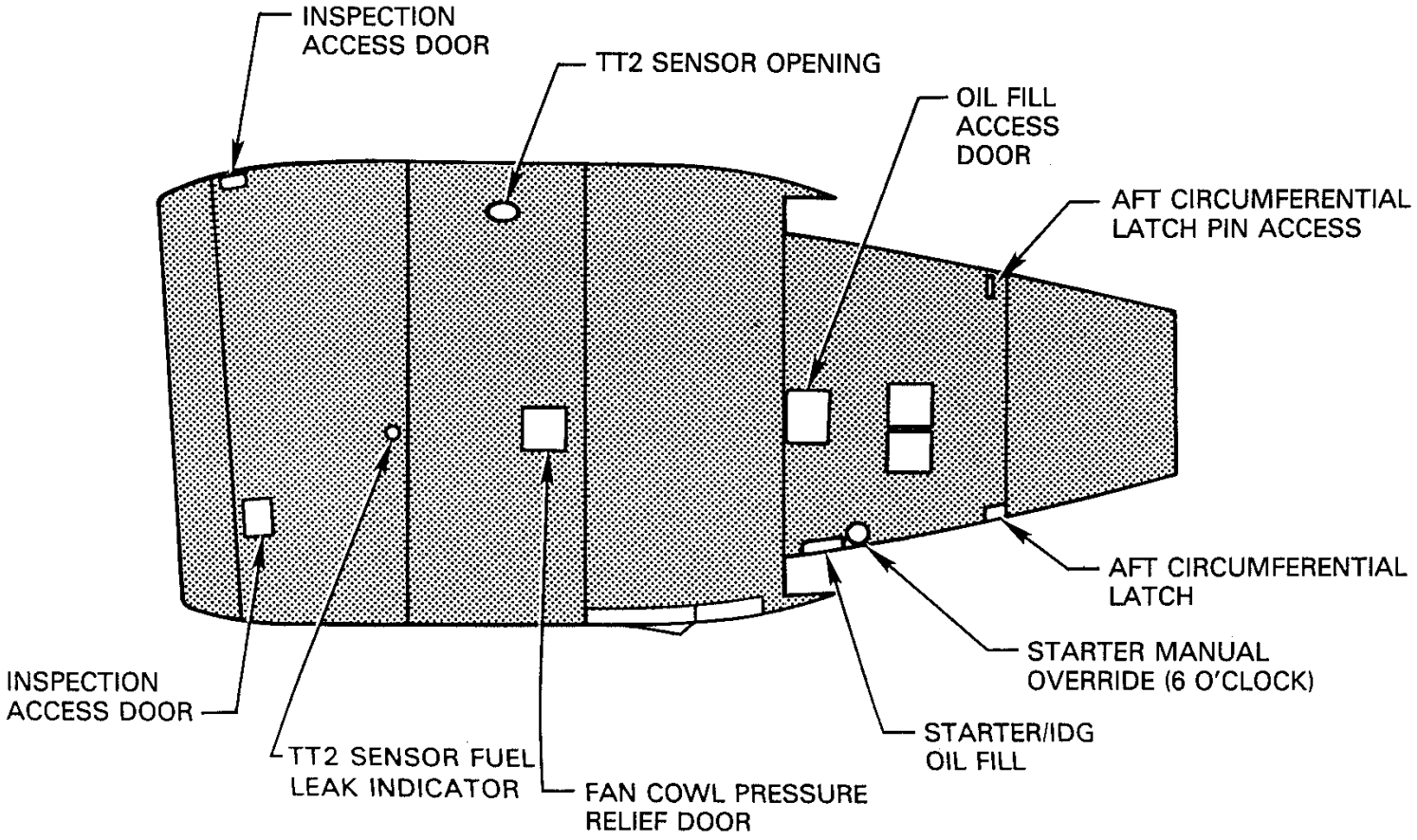
Engine Profile



CT4010.19970924

CT4010

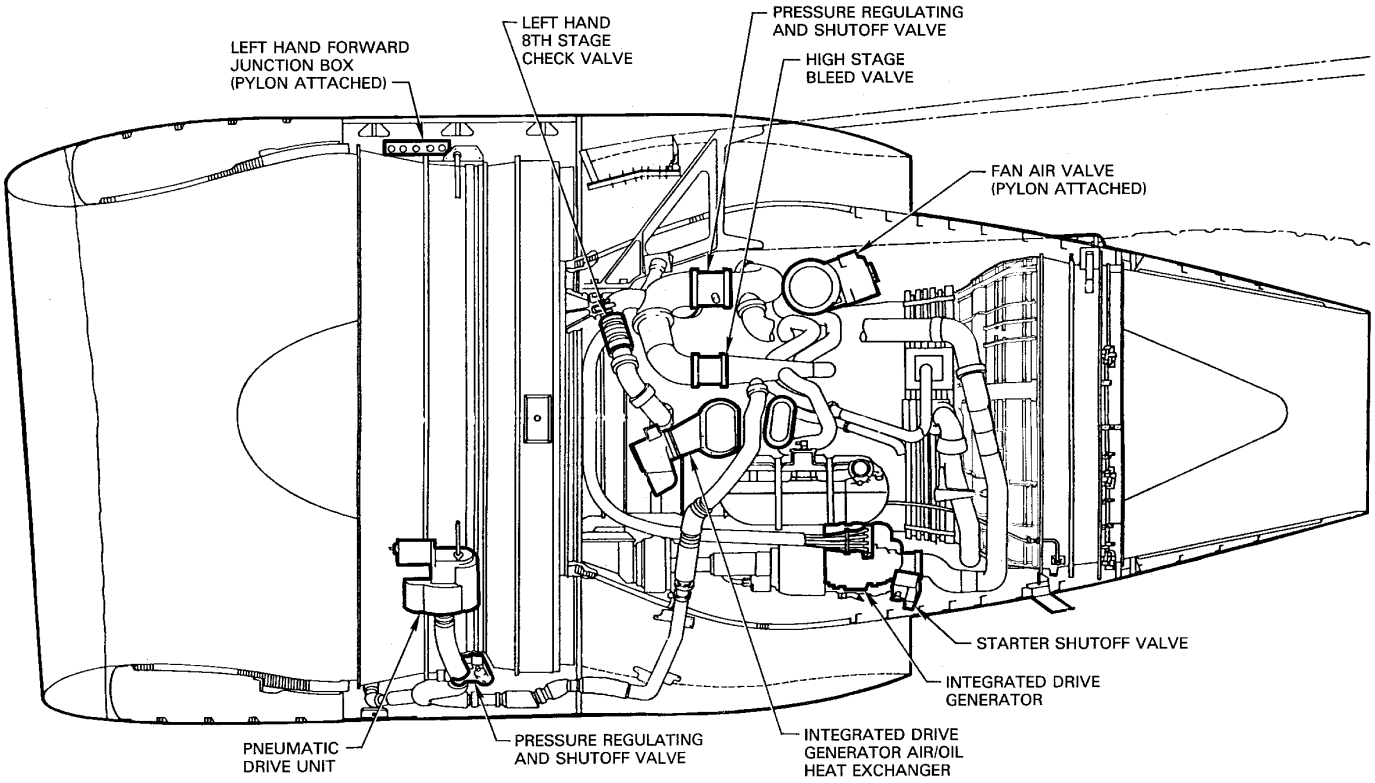
Nacelle Access (Left Side)



CT4031.19970924

CT4031

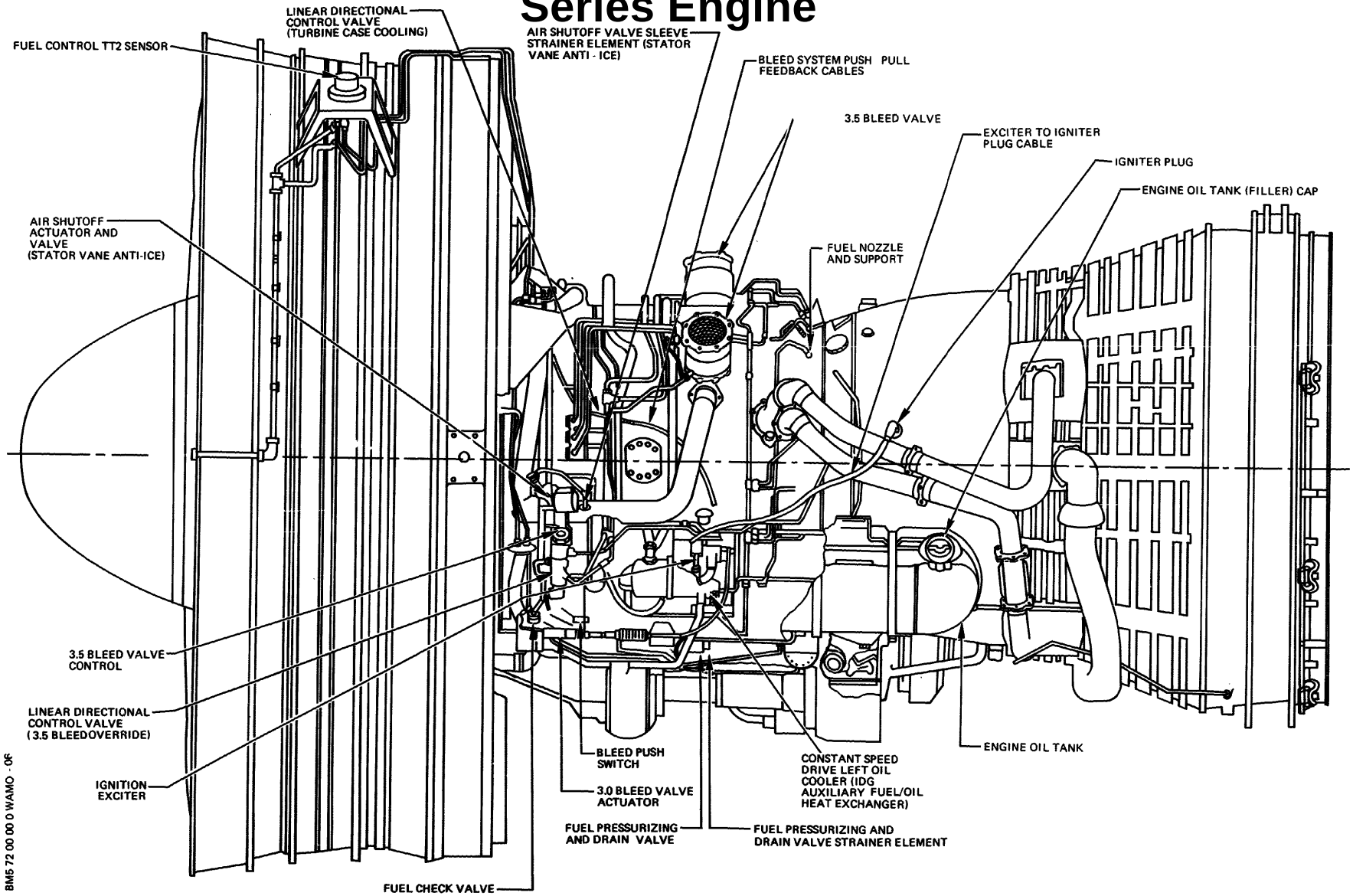
Engine Build Unit (EBU) Components - Left Side


LEFT HAND FORWARD JUNCTION BOX (PYLON ATTACHED)
LEFT HAND 8TH STAGE CHECK VALVE
PRESSURE REGULATING AND SHUTOFF VALVE
HIGH STAGE BLEED VALVE
FAN AIR VALVE (PYLON ATTACHED)
STARTER SHUTOFF VALVE
INTEGRATED DRIVE GENERATOR
INTEGRATED DRIVE GENERATOR AIR/OIL HEAT EXCHANGER
PRESSURE REGULATING AND SHUTOFF VALVE
PNEUMATIC DRIVE UNIT

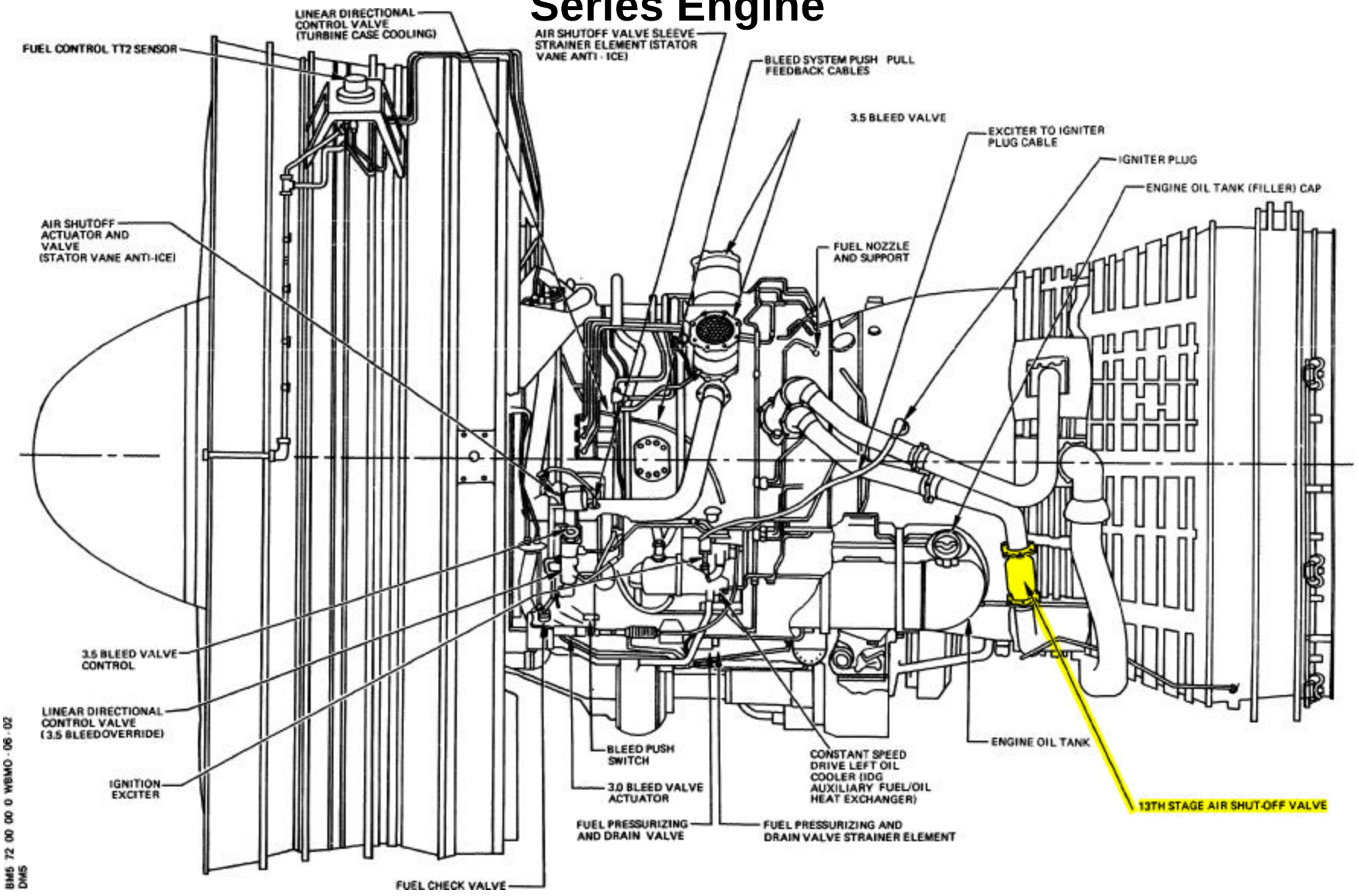
CTF4177.19970924

CT4177

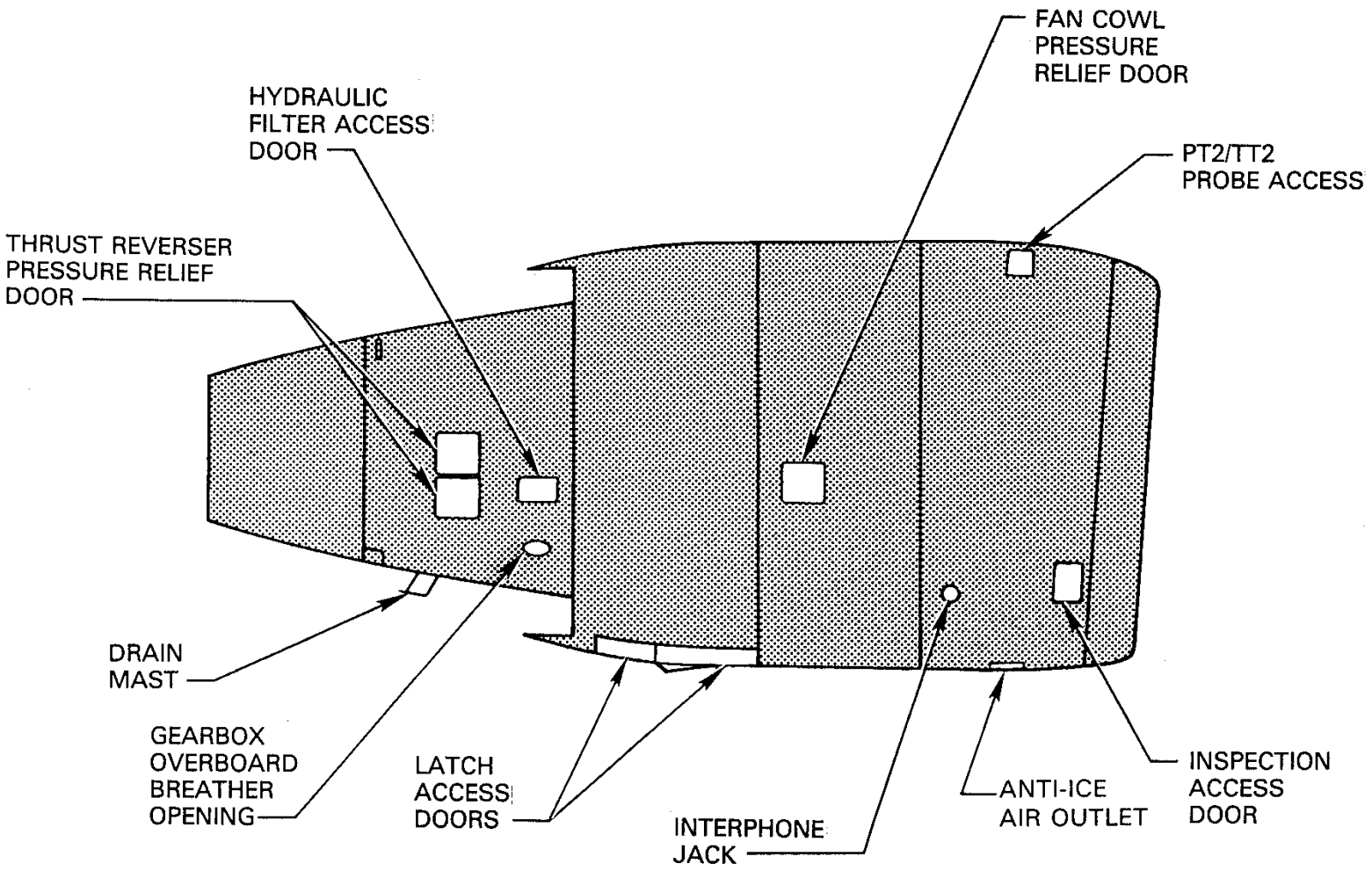
Component Location – Left Side for AI 500 Series Engine


LINEAR DIRECTIONAL CONTROL VALVE (TURBINE CASE COOLING)
FUEL CONTROL TT2 SENSOR
AIR SHUTOFF VALVE SLEEVE STRAINER ELEMENT (STATOR VANE ANTI - ICE)
BLEED SYSTEM PUSH PULL FEEDBACK CABLES
3.5 BLEED VALVE
EXCITER TO IGNITER PLUG CABLE
IGNITER PLUG
ENGINE OIL TANK (FILLER) CAP
AIR SHUTOFF ACTUATOR AND VALVE (STATOR VANE ANTI-ICE)
FUEL NOZZLE AND SUPPORT
3.5 BLEED VALVE CONTROL
LINEAR DIRECTIONAL CONTROL VALVE (3.5 BLEEDOVERRIDE)
IGNITION EXCITER
BLEED PUSH SWITCH
3.0 BLEED VALVE ACTUATOR
FUEL PRESSURIZING AND DRAIN VALVE
CONSTANT SPEED DRIVE LEFT OIL COOLER (IDG AUXILIARY FUEL/OIL HEAT EXCHANGER)
FUEL PRESSURIZING AND DRAIN VALVE STRAINER ELEMENT
ENGINE OIL TANK
FUEL CHECK VALVE
BM5 72 00 00 0 WAMO - 06

Component Location – Left Side for AI 600 Series Engine


FUEL CONTROL TT2 SENSOR
LINEAR DIRECTIONAL CONTROL VALVE (TURBINE CASE COOLING)
AIR SHUTOFF VALVE SLEEVE STRAINER ELEMENT (STATOR VANE ANTI - ICE)
BLEED SYSTEM PUSH PULL FEEDBACK CABLES
3.5 BLEED VALVE
EXCITER TO IGNITER PLUG CABLE
IGNITER PLUG
ENGINE OIL TANK (FILLER) CAP
AIR SHUTOFF ACTUATOR AND VALVE (STATOR VANE ANTI-ICE)
FUEL NOZZLE AND SUPPORT
3.5 BLEED VALVE CONTROL
LINEAR DIRECTIONAL CONTROL VALVE (3.5 BLEEDOVERRIDE)
IGNITION EXCITER
BLEED PUSH SWITCH
3.0 BLEED VALVE ACTUATOR
FUEL PRESSURIZING AND DRAIN VALVE
CONSTANT SPEED DRIVE LEFT OIL COOLER (IDG AUXILIARY FUEL/OIL HEAT EXCHANGER)
FUEL PRESSURIZING AND DRAIN VALVE STRAINER ELEMENT
ENGINE OIL TANK
13TH STAGE AIR SHUT-OFF VALVE
FUEL CHECK VALVE
BM5 72 00 00 0 WBMO-06-02
DM5

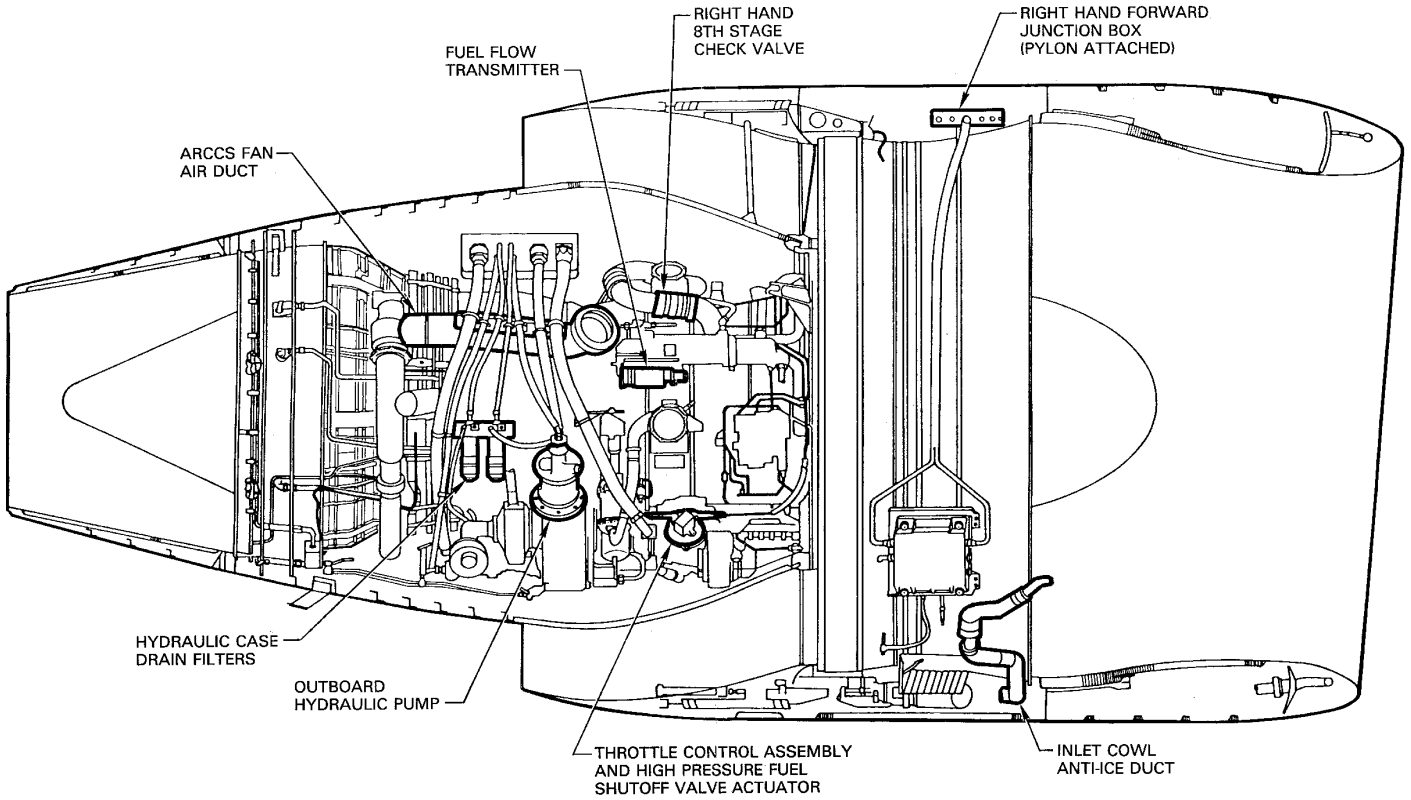
Nacelle Access (Right Side)



CT4032.19970924

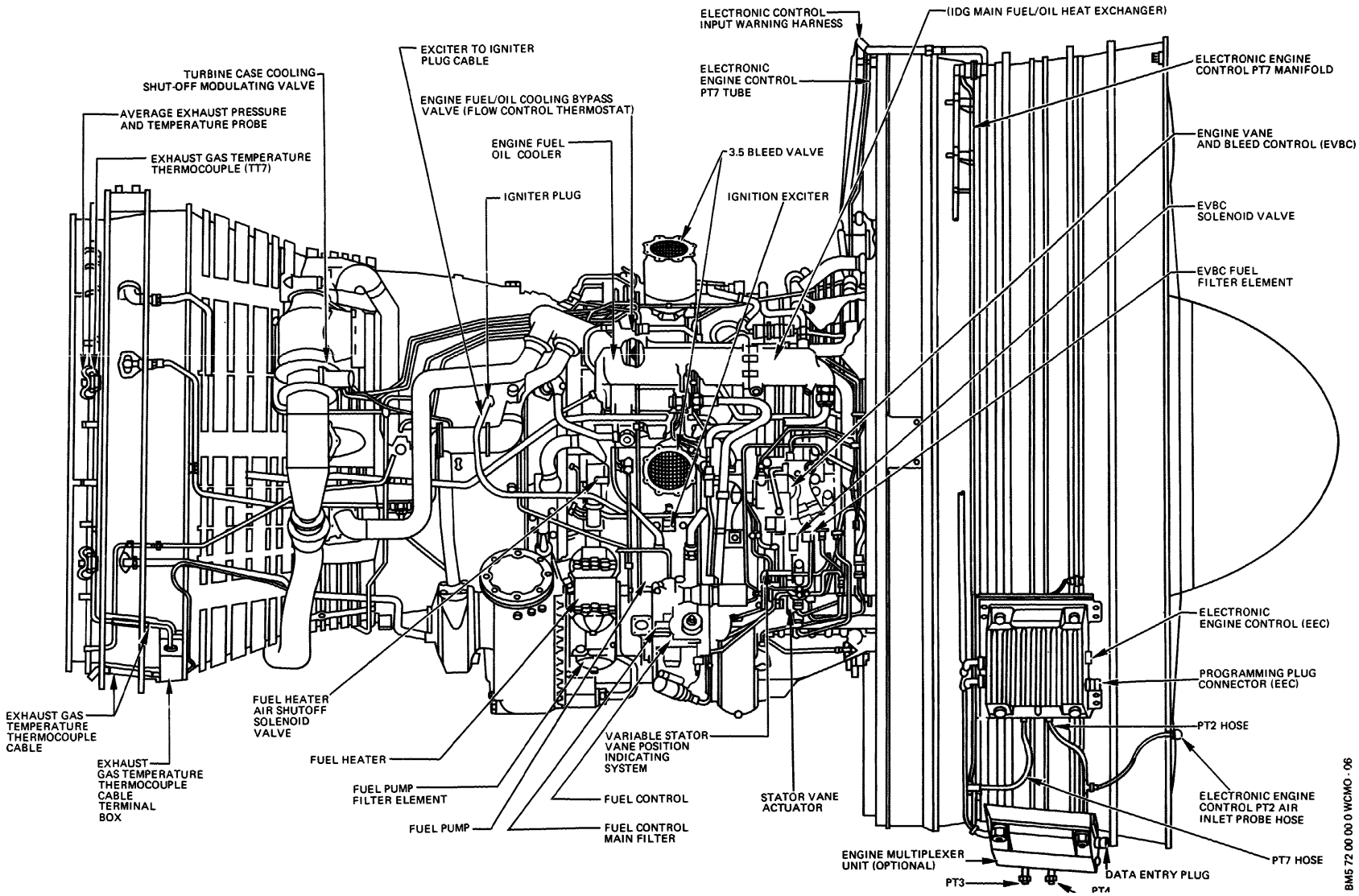
CT4032

Engine Build Unit (EBU) Components - Right Side

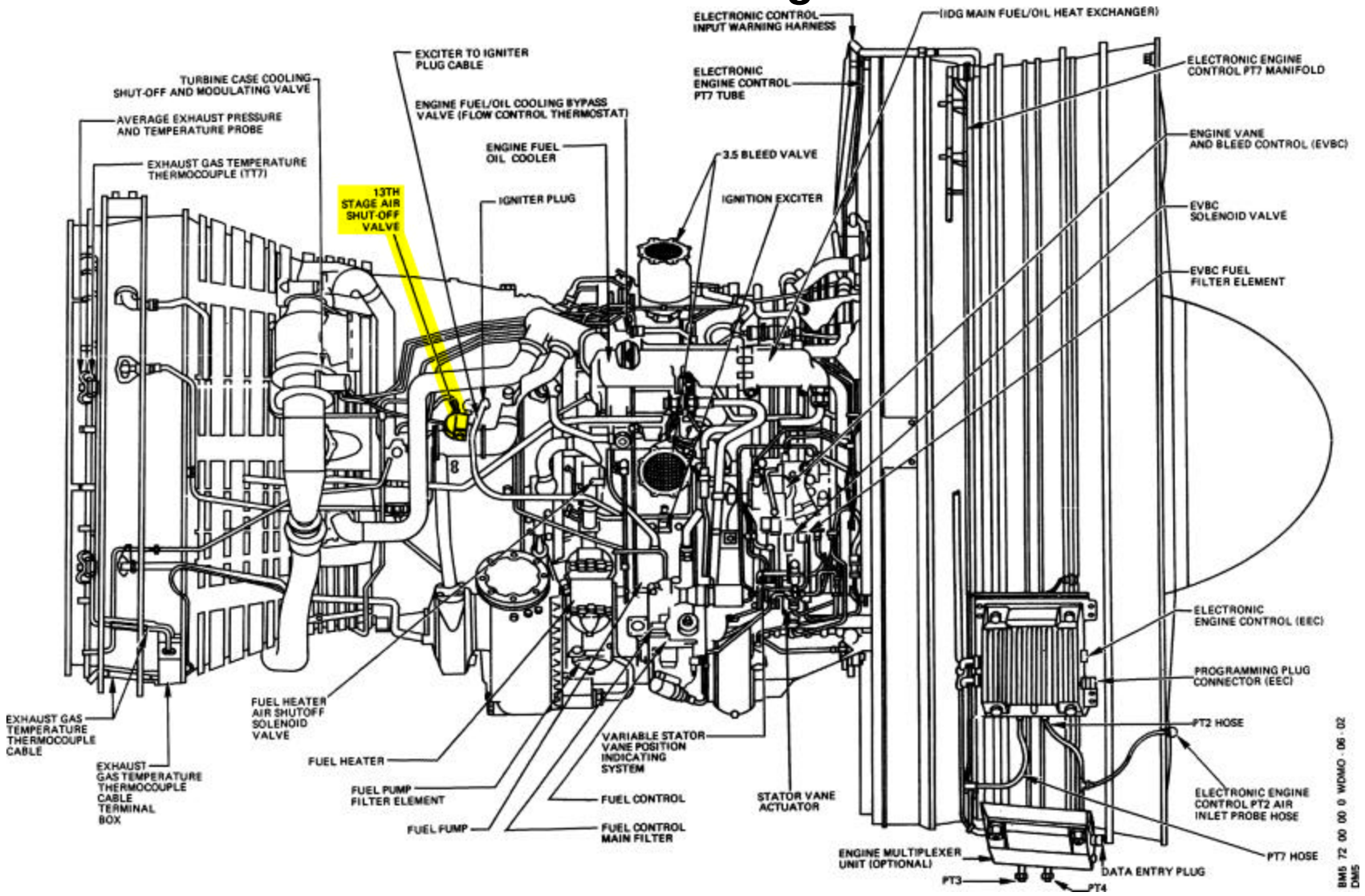


CT4180

Component Location – Right Side for AI 500 Series Engine


ELECTRONIC CONTROL INPUT WARNING HARNESS
(IDG MAIN FUEL/OIL HEAT EXCHANGER)
EXCITER TO IGNITER PLUG CABLE
TURBINE CASE COOLING SHUT-OFF MODULATING VALVE
ELECTRONIC ENGINE CONTROL PT7 TUBE
ELECTRONIC ENGINE CONTROL PT7 MANIFOLD
ENGINE FUEL/OIL COOLING BYPASS VALVE (FLOW CONTROL THERMOSTAT)
AVERAGE EXHAUST PRESSURE AND TEMPERATURE PROBE
ENGINE FUEL OIL COOLER
3.5 BLEED VALVE
ENGINE VANE AND BLEED CONTROL (EVBC)
EXHAUST GAS TEMPERATURE THERMOCOUPLE (TT7)
IGNITER PLUG
IGNITION EXCITER
EVBC SOLENOID VALVE
EVBC FUEL FILTER ELEMENT
ELECTRONIC ENGINE CONTROL (EEC)
PROGRAMMING PLUG CONNECTOR (EEC)
PT2 HOSE
EXHAUST GAS TEMPERATURE THERMOCOUPLE CABLE
FUEL HEATER AIR SHUTOFF SOLENOID VALVE
VARIABLE STATOR VANE POSITION INDICATING SYSTEM
EXHAUST GAS TEMPERATURE THERMOCOUPLE CABLE TERMINAL BOX
FUEL HEATER
FUEL PUMP FILTER ELEMENT
FUEL CONTROL
STATOR VANE ACTUATOR
ELECTRONIC ENGINE CONTROL PT2 AIR INLET PROBE HOSE
FUEL PUMP
FUEL CONTROL MAIN FILTER
ENGINE MULTIPLEXER UNIT (OPTIONAL)
PT7 HOSE
DATA ENTRY PLUG
PT3
BM5 72 00 00 0 WCMO - 06

Component Location – Right Side for AI 600 Series Engine


ELECTRONIC CONTROL INPUT WARNING HARNESS
IDG MAIN FUEL/OIL HEAT EXCHANGER
EXCITER TO IGNITER PLUG CABLE
TURBINE CASE COOLING SHUT-OFF AND MODULATING VALVE
ELECTRONIC ENGINE CONTROL PT7 TUBE
ELECTRONIC ENGINE CONTROL PT7 MANIFOLD
AVERAGE EXHAUST PRESSURE AND TEMPERATURE PROBE
ENGINE FUEL/OIL COOLING BYPASS VALVE (FLOW CONTROL THERMOSTAT)
ENGINE VANE AND BLEED CONTROL (EVBC)
EXHAUST GAS TEMPERATURE THERMOCOUPLE (TT7)
ENGINE FUEL OIL COOLER
3.5 BLEED VALVE
13TH STAGE AIR SHUT-OFF VALVE
IGNITER PLUG
IGNITION EXCITER
EVBC SOLENOID VALVE
EVBC FUEL FILTER ELEMENT
ELECTRONIC ENGINE CONTROL (EEC)
PROGRAMMING PLUG CONNECTOR (EEC)
PT2 HOSE
EXHAUST GAS TEMPERATURE THERMOCOUPLE CABLE
FUEL HEATER AIR SHUTOFF SOLENOID VALVE
VARIABLE STATOR VANE POSITION INDICATING SYSTEM
EXHAUST GAS TEMPERATURE THERMOCOUPLE CABLE TERMINAL BOX
FUEL HEATER
FUEL PUMP FILTER ELEMENT
FUEL CONTROL
STATOR VANE ACTUATOR
ELECTRONIC ENGINE CONTROL PT2 AIR INLET PROBE HOSE
FUEL PUMP
FUEL CONTROL MAIN FILTER
PT7 HOSE
ENGINE MULTIPLEXER UNIT (OPTIONAL)
DATA ENTRY PLUG
PT3
PT4
BM5 72 00 00 0 WD4MO - 06 - 02 DM5

Forward/Aft Mounts

FORWARD MOUNT

Purpose:

- The forward mount is used to transfer vertical, side, and thrust loads to the pylon.

Location:

- The forward mount attaches to the intermediate case at the U flange (12:00 position).

Description and Operation:

- Main beam bolts to the pylon mount
- Left and right engine thrust links transfer thrust loads to the cross-beam
- Spherical bearing transmits side loads, vertical loads and reduces intermediate case distortion

AFT MOUNT

Purpose:

- The aft mount is used to transfer vertical, side, and torsional loads to the pylon.

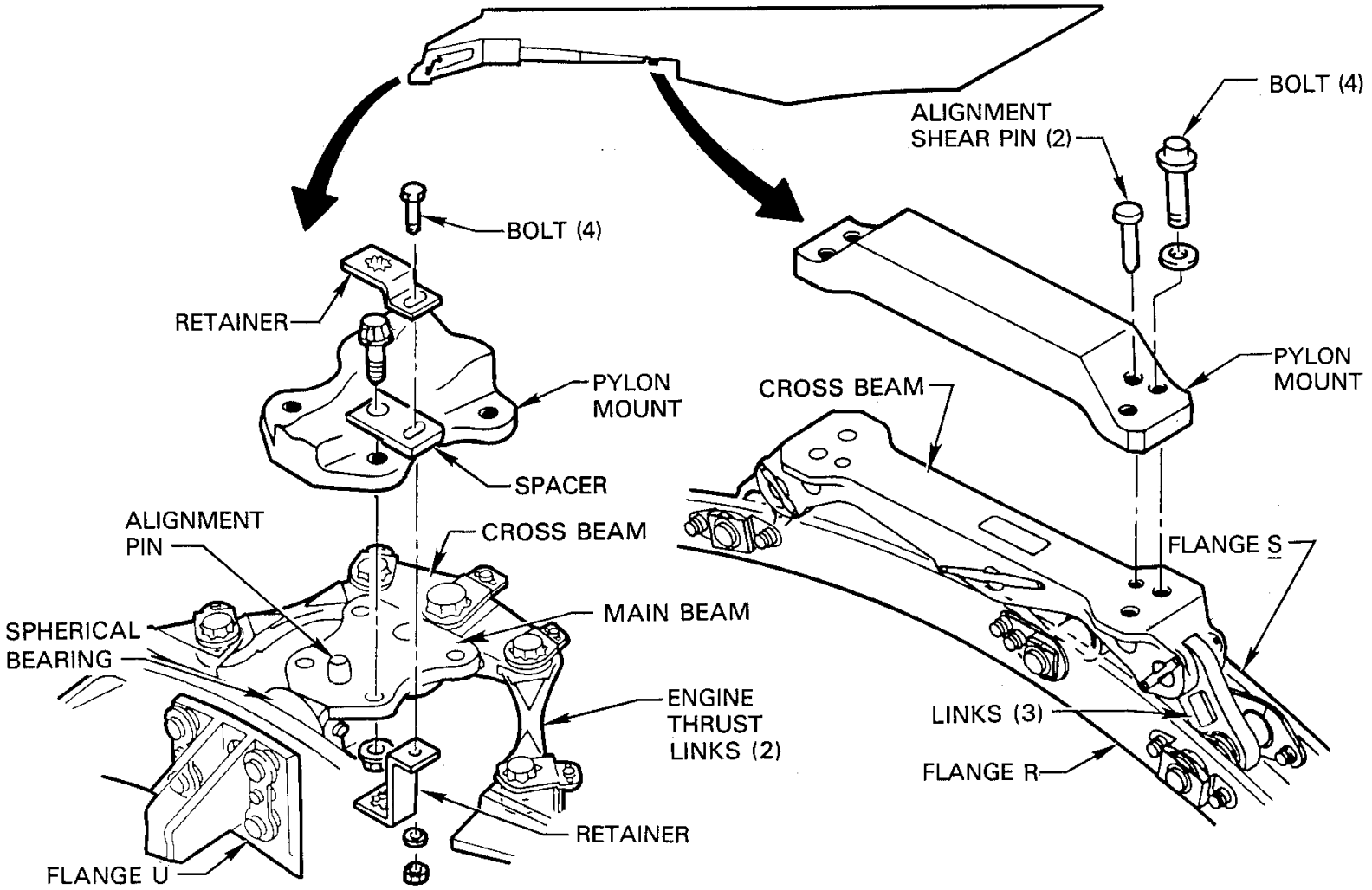
Location:

- The aft mount is found on the turbine exhaust case at the 12:00 position.

Description and Operation:

- Cross beam bolts to the pylon mount
- Links transfer loads to pylon
- Slight fore and aft movement to accommodate thermal growth

Forward and Aft Mounts

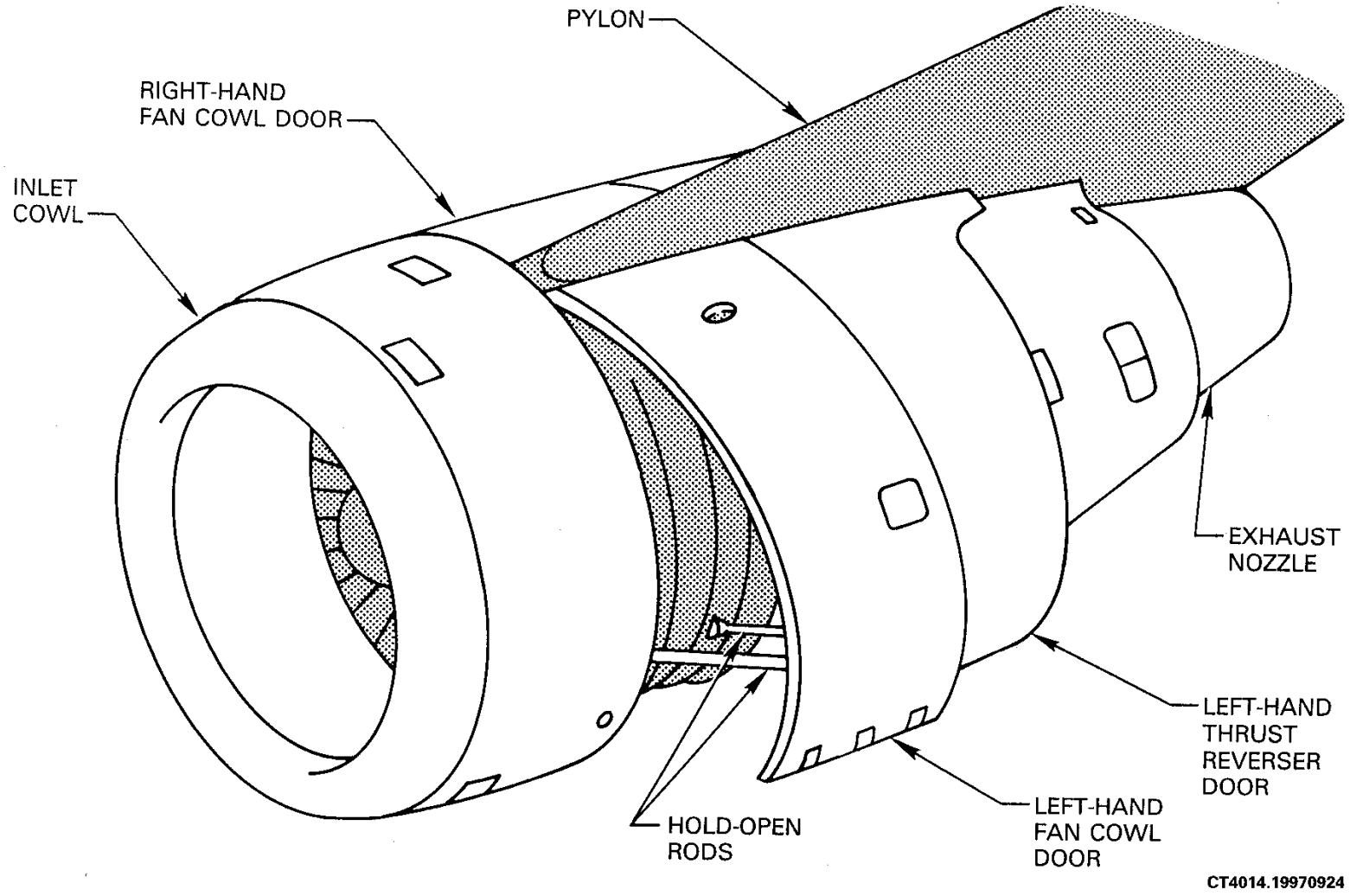


CT4012

Components Installed

- Inlet cowl
  - Attaches to the fan case at the A flange
- Fan cowl doors
  - Pylon hinged
  - Secured closed by the lower centerline latches
  - Manually opened and closed
  - Secured in open position by telescoping hold-open rods
- Thrust reverser doors
  - Pylon hinged
  - Secured closed by network of eight latches
  - Hydraulically opened
  - Secured in open position by telescoping hold-open rods or hydraulic actuator safety lock
- Exhaust nozzle
  - Attaches to engine exhaust case at T flange
- Exhaust plug
  - Attaches to engine exhaust case at T1 flange

Nacelle Components (Installed)



CT4014

Inlet Cowl Assembly

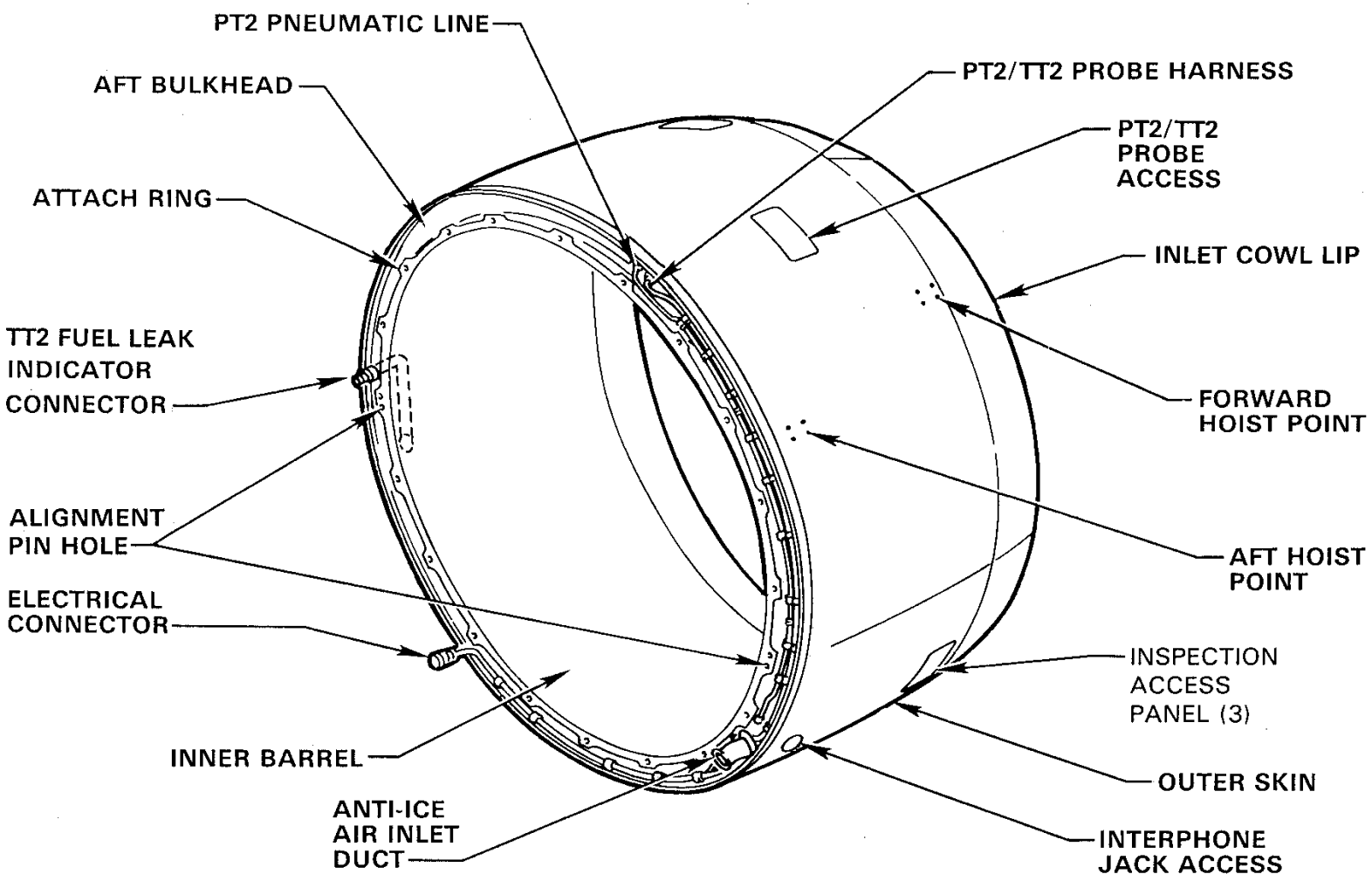
Purpose:

- Gives optimum airflow profile to the fan

Description and Operation:

- Attaches to engine A flange
- PT2 / TT2 probe
- PT2 / TT2 electrical harness and connector
- PT2 pneumatic line
- TT2 probe fuel leak indicator
- Anti-ice air inlet duct
- Interphone jack access
- Hoist points
- Anti-ice air outlet

Inlet Cowl Assembly



CT3292.19970924

CT3292

Fan Cowl Doors

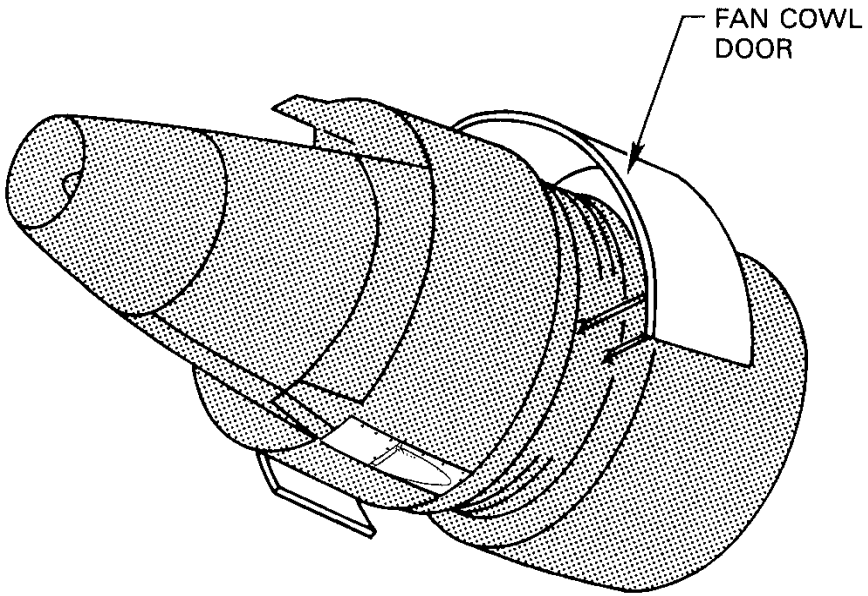
Purpose:

- Gives access to fan case-mounted accessories and thrust reverser door forward circumferential strap latches, and thrust reverser actuation system components.

Description and Operation:

- Hinged to pylon - three places
- Lower centerline tension latches - three places
- Manually opened / closed
- Fore and aft hold-open rods

Fan Cowl Doors



CT4033.19970924

CT4033

Fan Cowl Door Latches and Hinges

Purpose:

- Secure fan cowl doors in closed position and give easy opening for access to engine and thrust reverser components.

Description and Operation:

- Adjustable tension latches
- Lower centerline
  - Forward
  - Center
  - Aft

FAN COWL DOOR HINGES

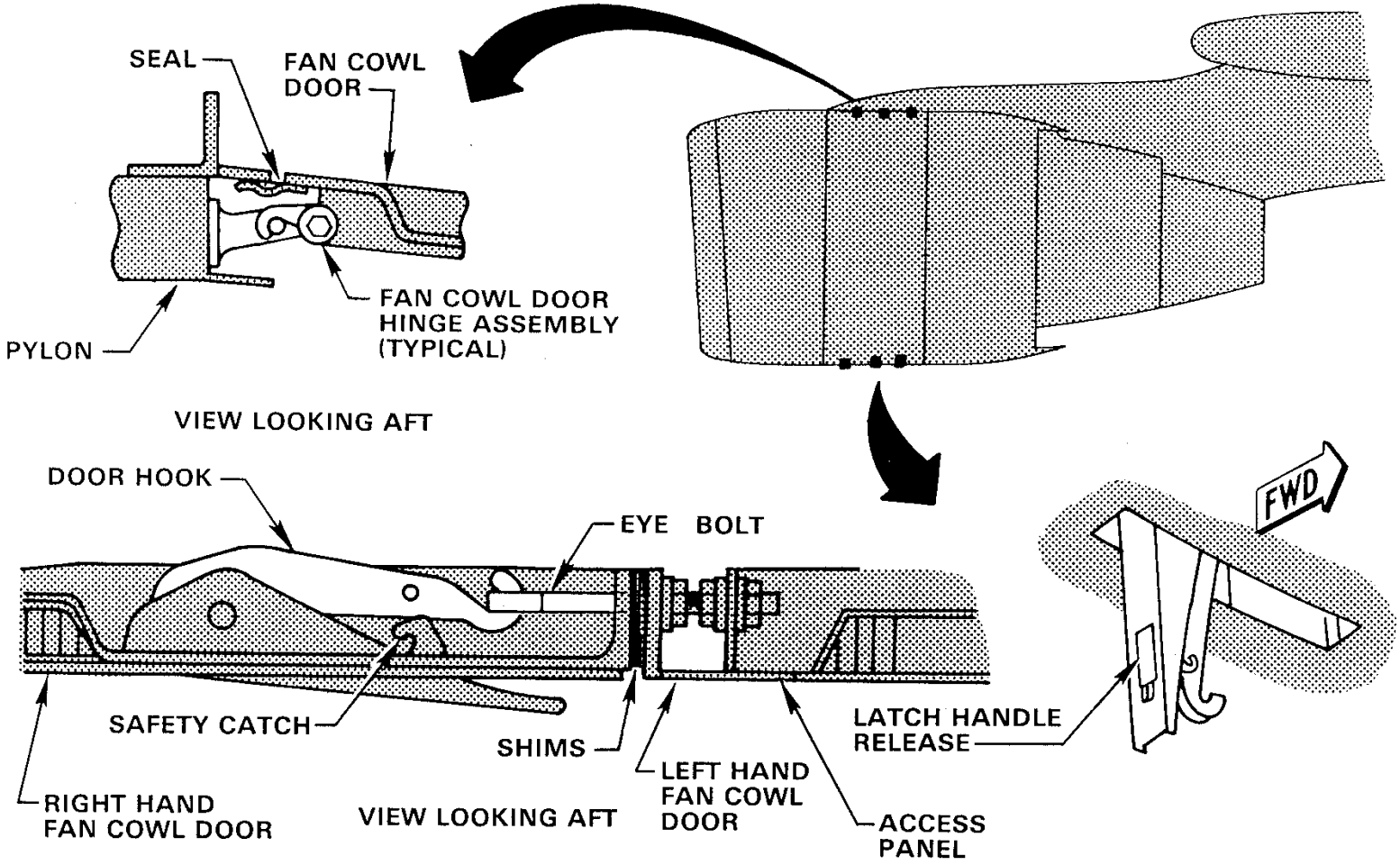
Purpose:

- Secure fan cowl doors to pylon.

Description and Operation:

- Pylon-mounted brackets
- Hinges are integral with the fan cowl door
  - Forward
  - Center
  - Aft

Fan Cowl Door Latches and Hinges



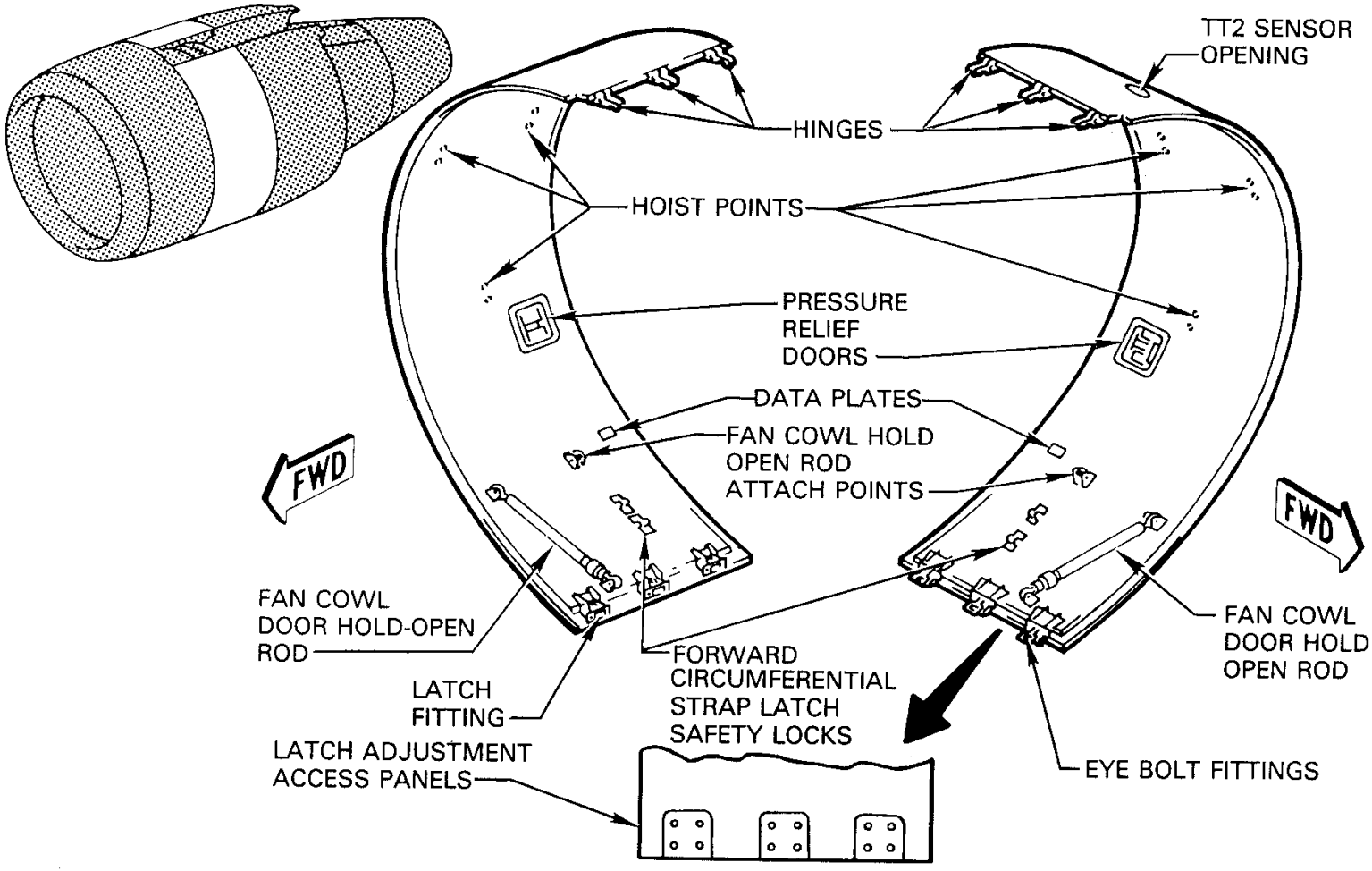
CT3295

Fan Cowl Doors

Description and Operation:

- Details:
  - Pressure relief doors
  - Hold-open rods
  - Latch fittings
  - Latch adjustment access panels - left hand door
  - TT2 sensor opening
  - Hoist points (3)
  - Hinges (3)
  - Forward circumferential strap latch safety locks

Fan Cowl Doors - Inside View



CT4034.19970924

CT4034

Thrust Reverser Doors

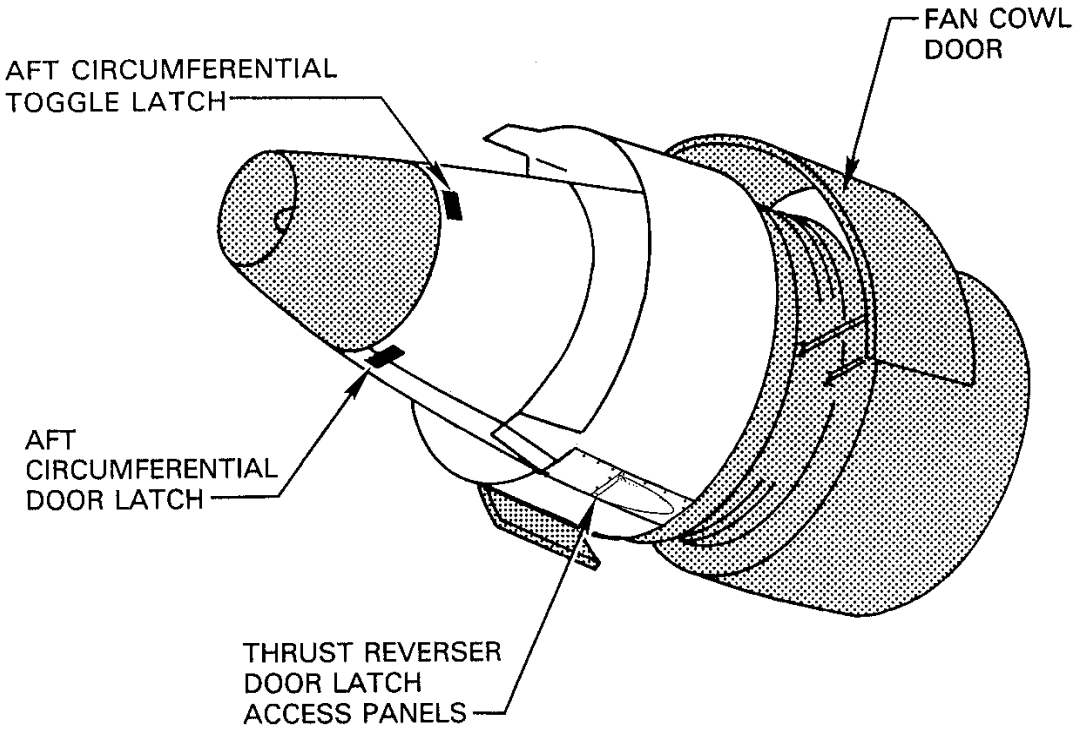
Purpose:

- Forms fan discharge ducts, gives access to core engine, and establishes load paths for cowl load sharing

Description and Operation:

- Hinged to pylon (3 per side)
- Secured closed with six latches and 2 toggle pins
- Hydraulically opened
- Has tracks and sliders for translating sleeves

Thrust Reverser Doors


FAN COWL DOOR
AFT CIRCUMFERENTIAL TOGGLE LATCH
AFT CIRCUMFERENTIAL DOOR LATCH
THRUST REVERSER DOOR LATCH ACCESS PANELS

CT4035.19970924

CT4035

Thrust Reverser Doors - Aft Circumferential Latches

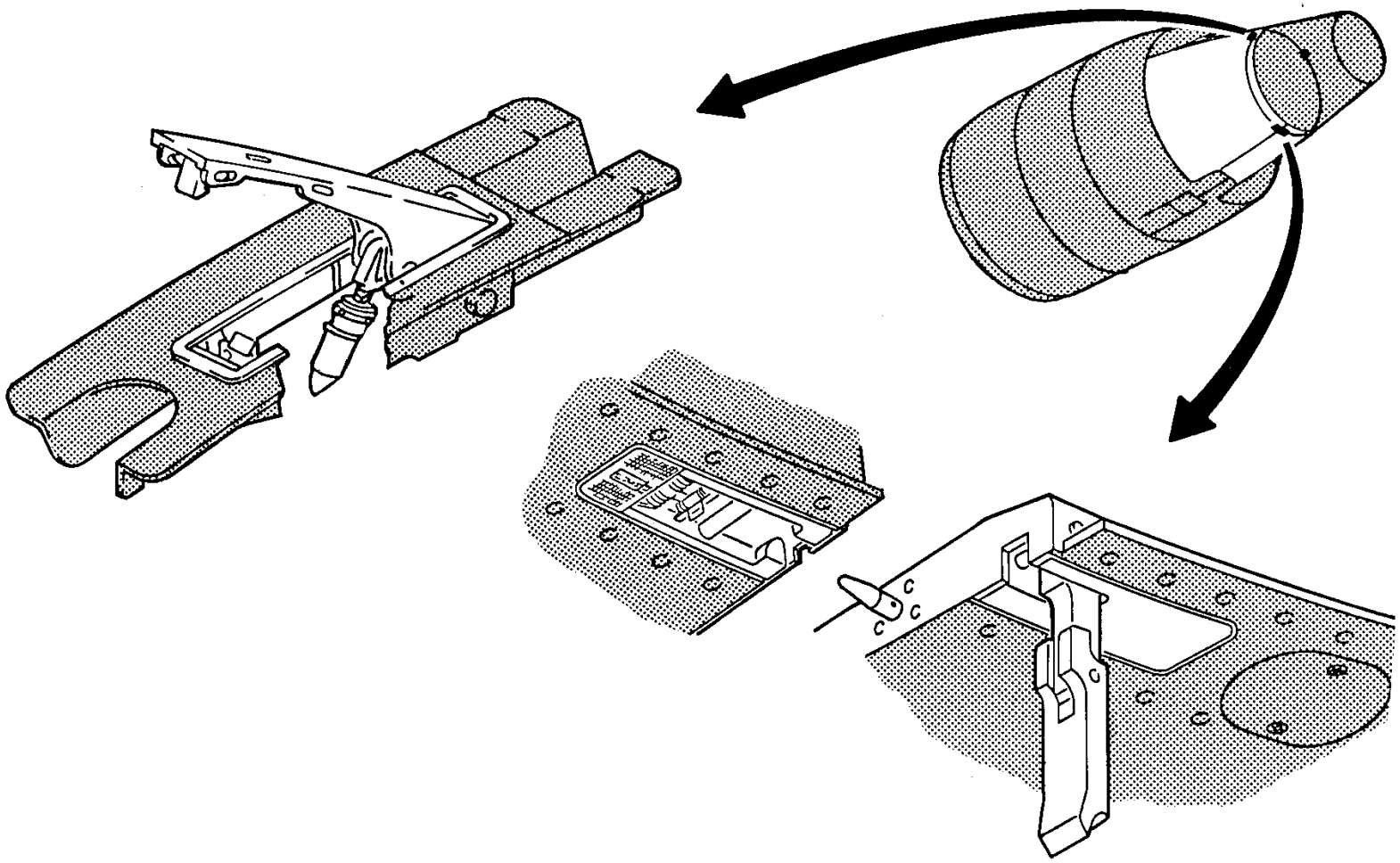
Purpose:

- Secure aft end of thrust reverser doors and supply cowl load sharing

Description and Operation:

- One adjustable tension latch at 6:00 position
- Two toggle latches (upper right and upper left) - manual or automatic
- Handle for lower tension latch in right thrust reverser door

Thrust Reverser Aft Circumferential Latches



CT4036.19970924

CT4036

Thrust Reverser Doors - Forward Circumferential Strap And Latches

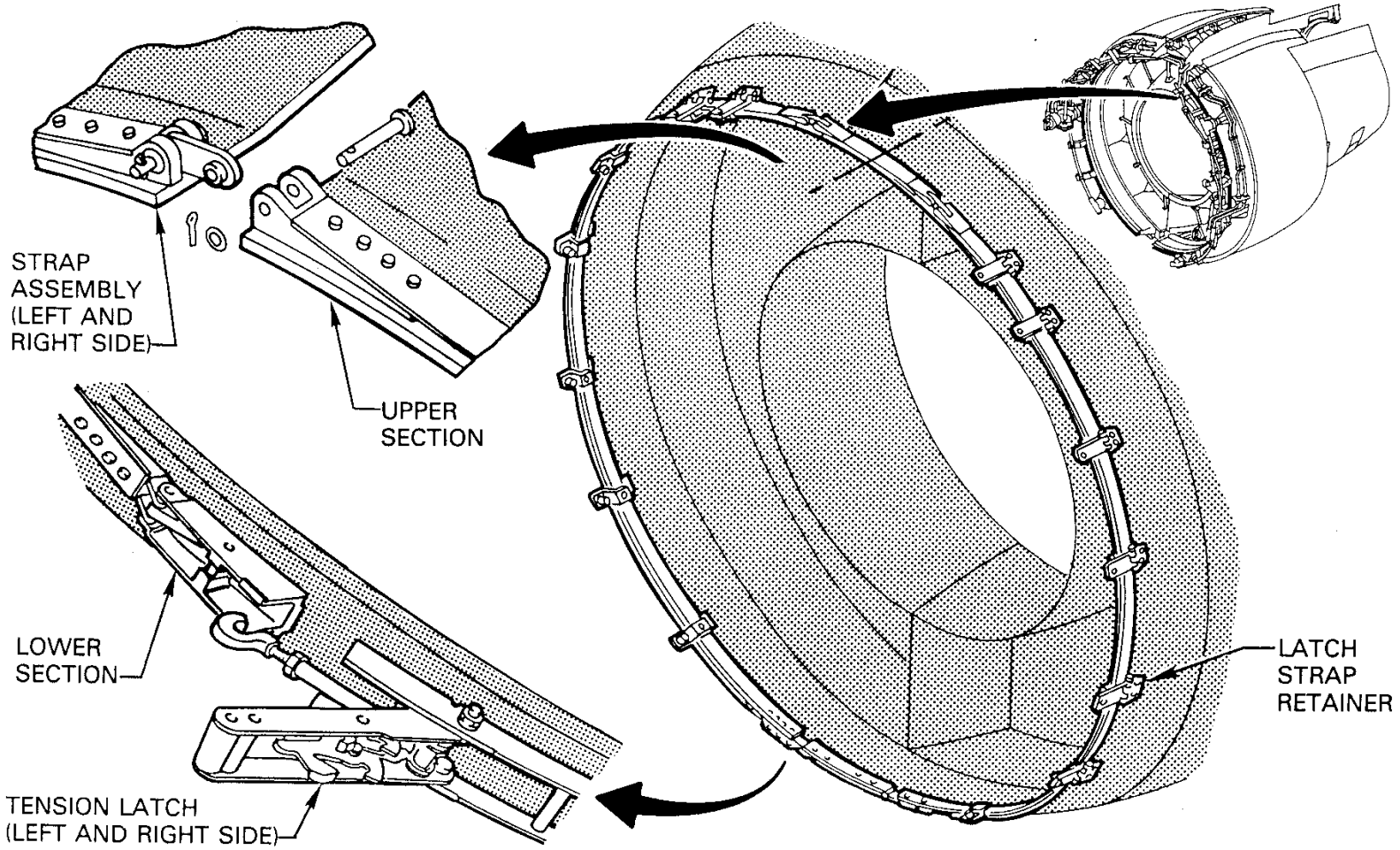
Purpose:

- Gives retention of the thrust reverser door in the event of a hinge or main latch failure and supplies cowl load sharing

Description and Operation:

- Access by opening fan cowl doors
- Upper section
  - Fastened to fan case at 12:00 position
  - Clevis ends
- Lower section
  - Fastened to fan case at 6:00 position
  - Has latch receivers
- Left side strap assembly section
  - Clevis pinned to upper section
  - Has tension latch
  - Found in retainers
- Right side strap assembly section
  - Clevis pinned to upper section
  - Has tension latch
  - Found in retainers

Thrust Reverser Forward Circumferential Latches



Engage and latch both latches at same time to prevent band from rotating. A310 AMM 71-13-03 page block 201(1,C,(b)

Thrust Reverser Doors - Door Center Latches

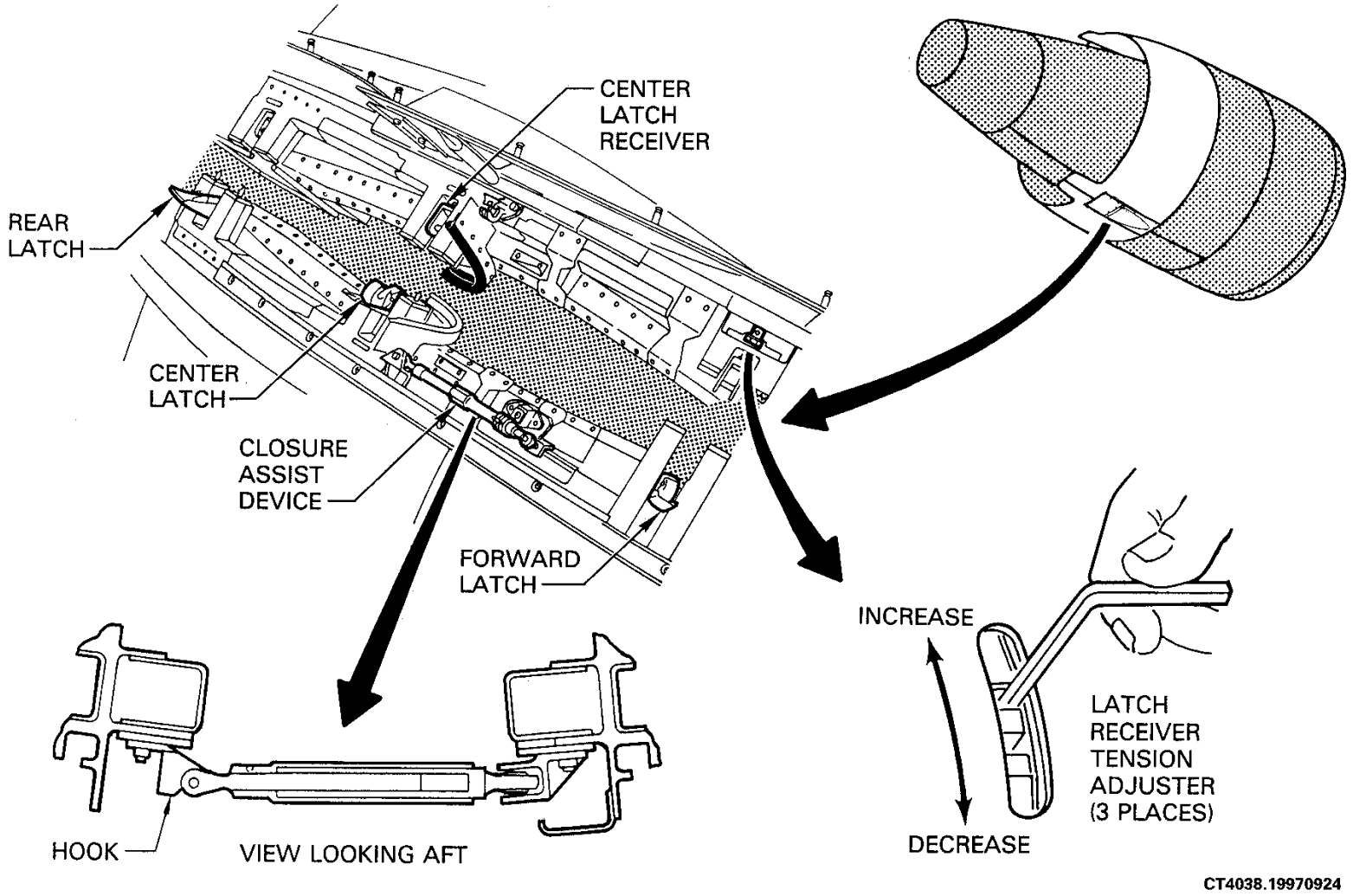
Purpose:

- Secure thrust reverser doors in closed position and supply cowl load sharing

Description and Operation:

- Three adjustable tension latches
- Latch handle in left door
- Eyebolt in right door
- Access through forward and aft latch access doors
- Has closure-assist device
- Latch opening sequence
  - Forward
  - Rear
  - Center
- Reverse sequence for closing

Thrust Reverser Door Center Latches



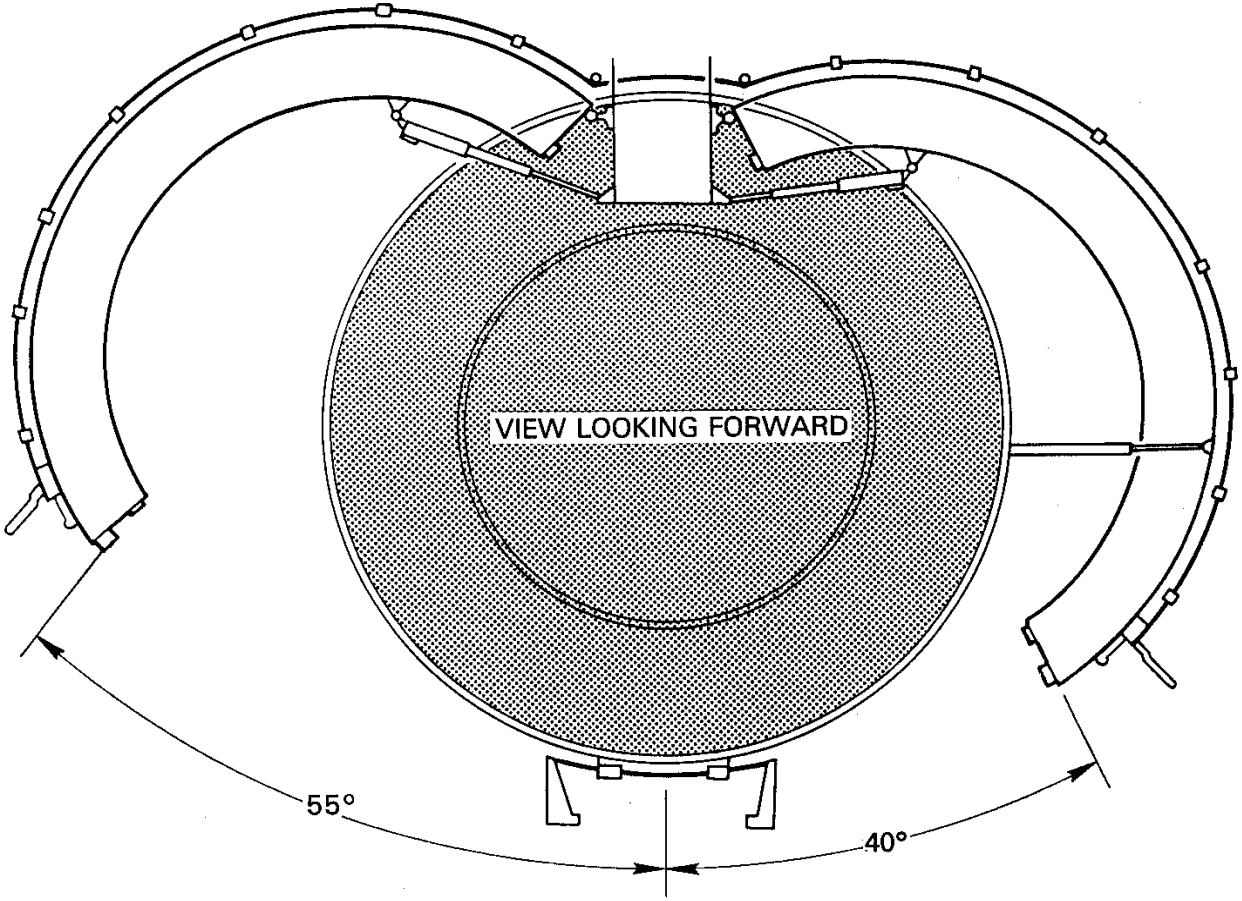
CT4038

Nacelle Configuration - Thrust Reverser Doors

Description and Operation:

- Opening procedure summary
  - Release aft and forward circumferential latches
    - Two forward
    - One aft
  - Release door center latches
    - Forward and rear latches
    - Center latch
  - Install hydraulic hand pump and open to angle degree desire
    - Manual forward and aft hold-open rods at 40° open
    - Safety lock fixture on actuator at 55° open

Thrust Reverser Door - Open Positions



CT4040.19970924

CT4040

Thrust Reverser Doors - Thrust Reverser Door Actuation System

Purpose:

- Give the capability to open the thrust reverser doors hydraulically

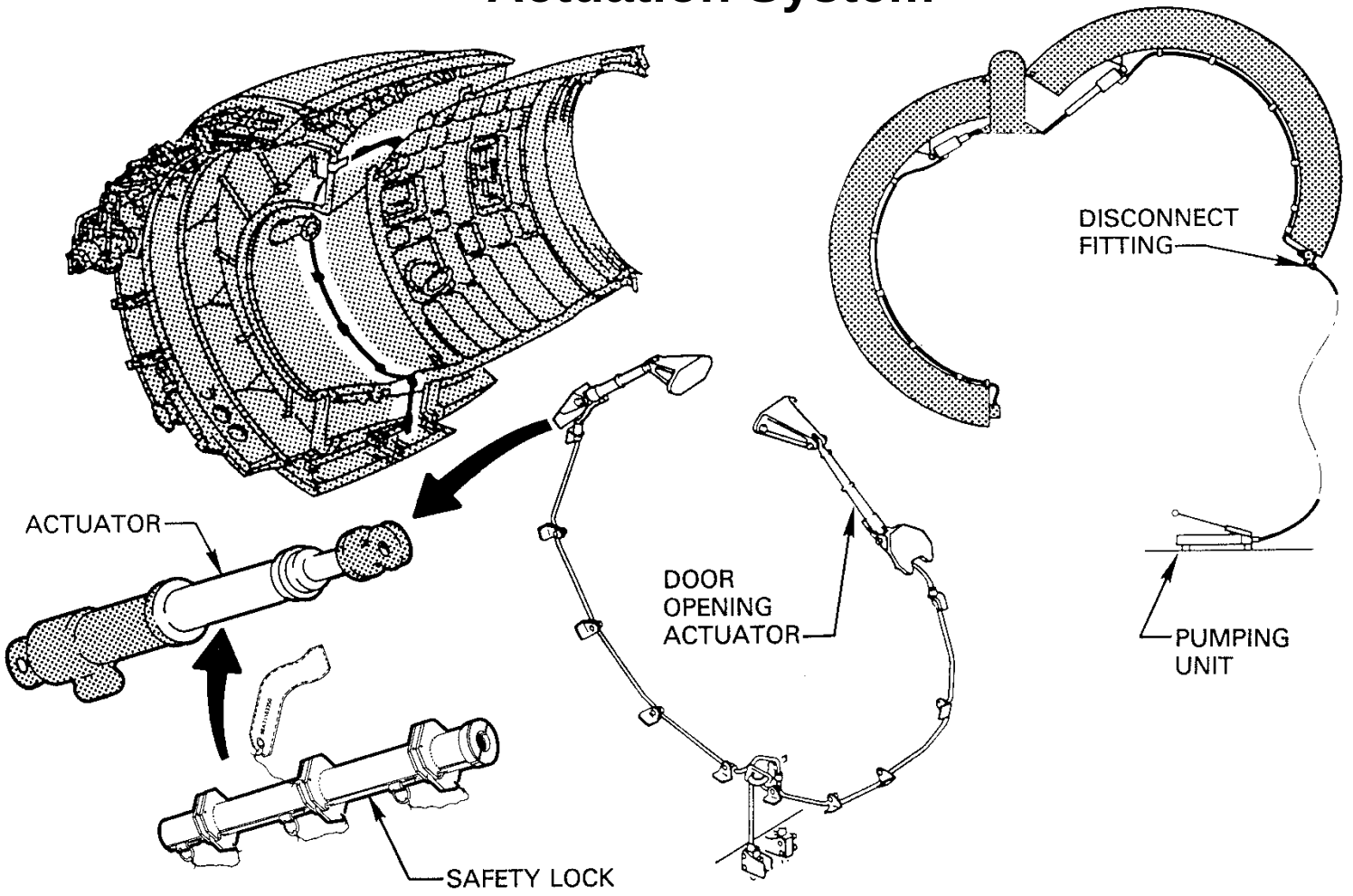
Components:

- Installed
  - Hydraulic actuators - top of doors
  - Hydraulic manifold - routed on door's inner wall
  - QAD fitting on the doors at the 6:00 position
- Ground support equipment
  - Hydraulic hand pump (RSE-1002-1 or equivalent)
  - Two-piece safety lock

Description and Operation:

- Hand pump attached to system at QAD to apply opening pressure
- Approximately 3 minutes to pump open
- To close doors release pump pressure slowly (20-26 seconds fall time)
- Actuators have bleeder orifices to control the rate of freefall for each door
- Two-piece safety lock installed on actuator to prevent accidental closure when fully opened

Thrust Reverser Door Hydraulic Opening Actuation System



CT4039.19970924

CT4039

Thrust Reverser Door Hold-Open Rods

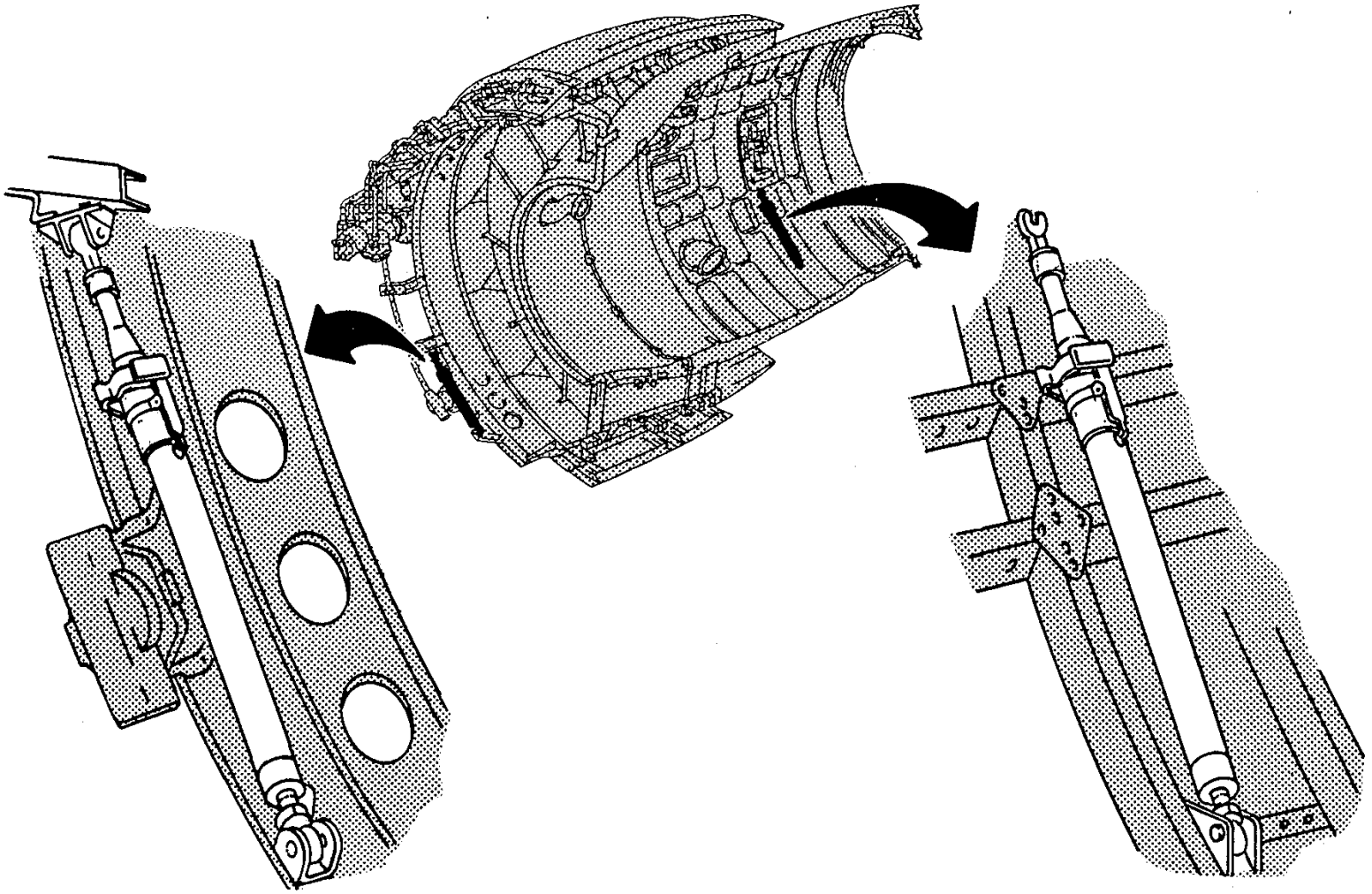
Purpose:

- Secure thrust reverser doors in 40° open positron

Description and Operation:

- Telescoping rods
  - Forward
  - Aft
- Stowed on thrust reverser door
- Has positive locking feature

Thrust Reverser Door Forward and Aft Hold-Open Rods



CT3316.19970924

Exhaust Nozzle and Plug

EXHAUST NOZZLE

Purpose:

- Converts primary gas flow to primary thrust

Description and Operation:

- Attaches to engine exhaust case at T flange
- Supports station 200 cowl load sharing strap and toggle pin receivers.

EXHAUST PLUG

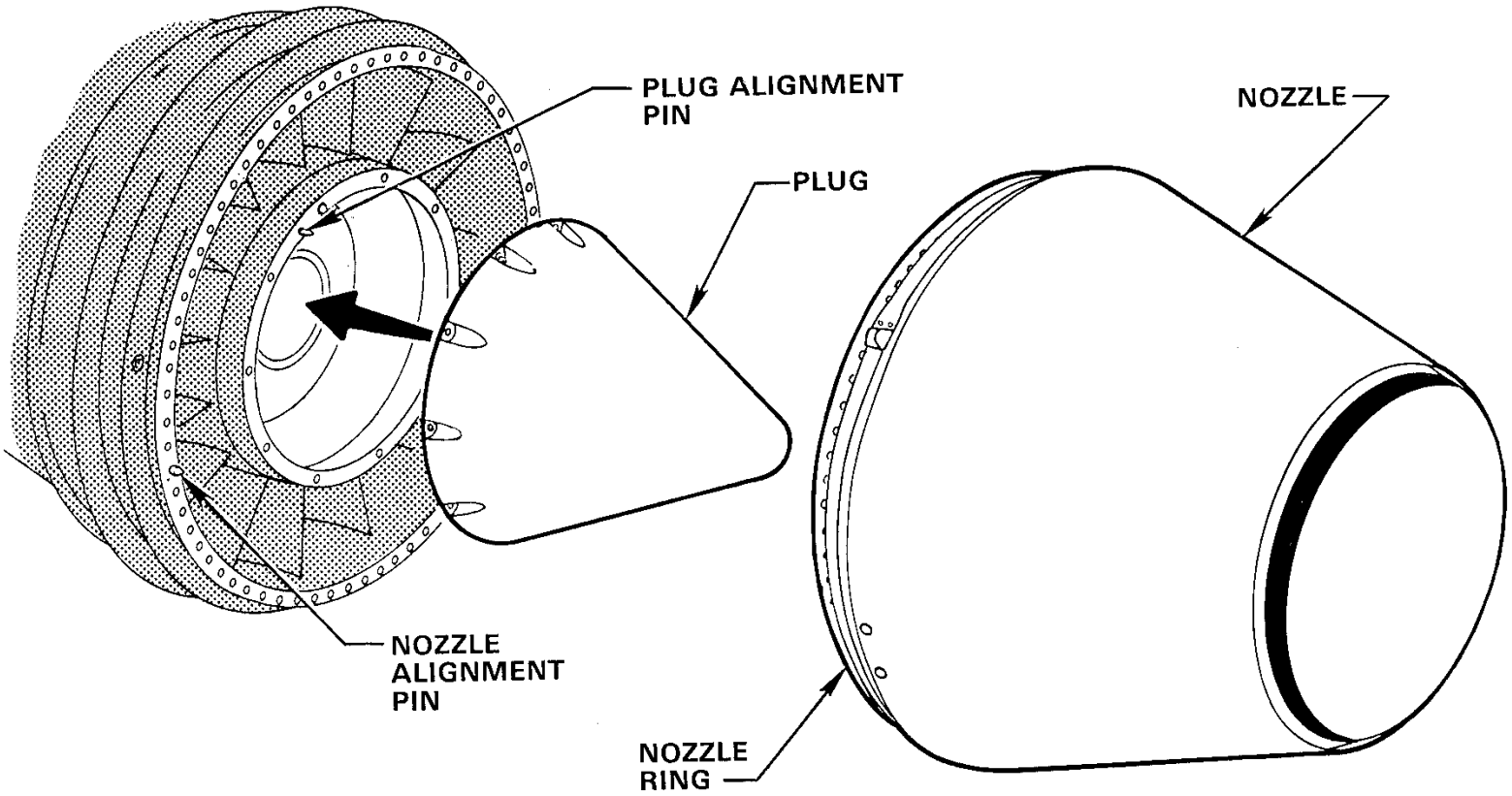
Purpose:

- Forms inner contour of primary exhaust annulus

Description and Operation:

- Attaches to engine exhaust case at T1 flange

Exhaust Nozzle and Plug Assembly



See A310 AMM 71-00-00 for limits on exhaust nozzle and plug

CT3317.19970924

CT3317

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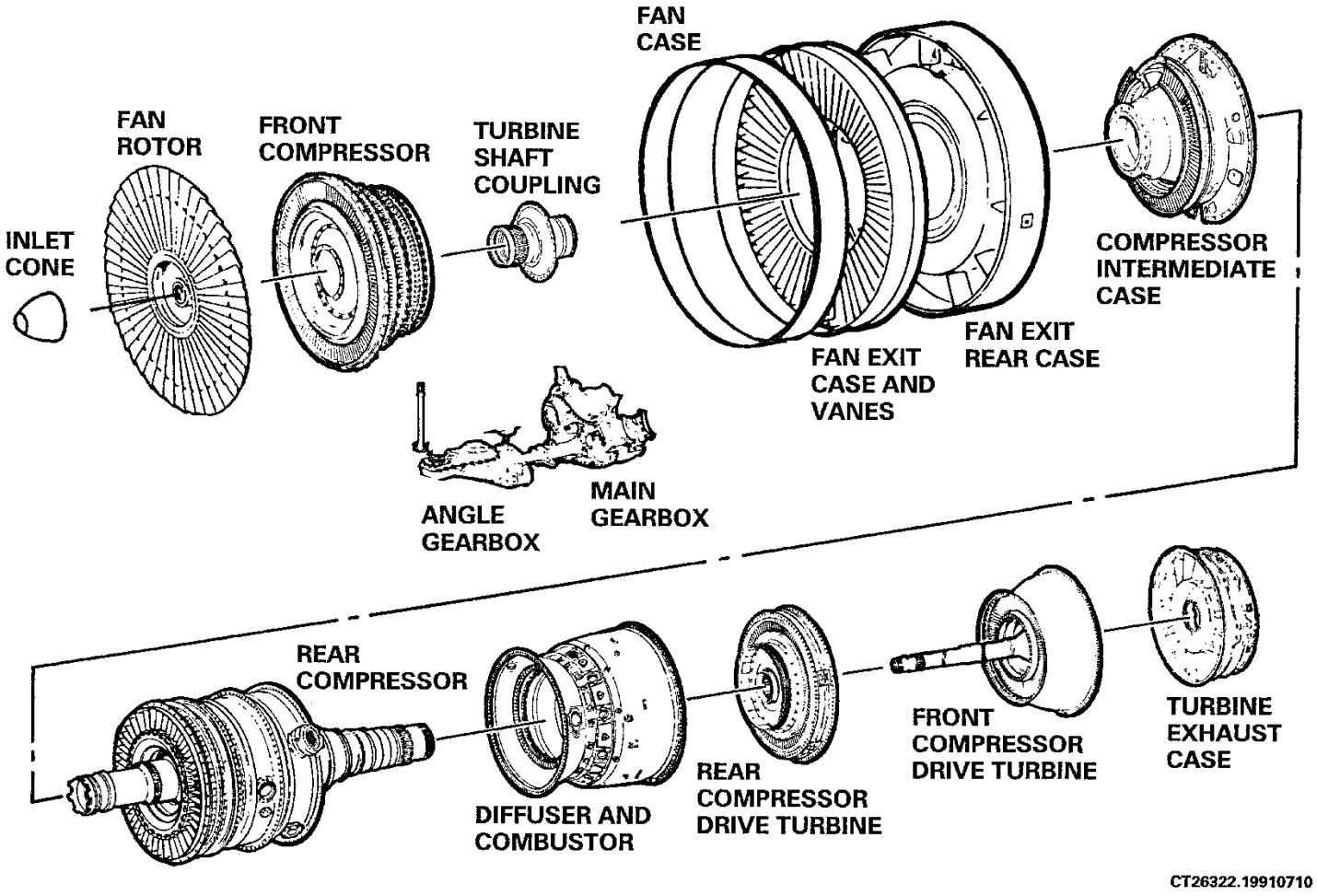
ENGINE CONFIGURATION

Overview

Major Assemblies

- Inlet cone:
  - Two piece (Kevlar)
- Fan rotor:
  - Forty blades
  - Replaceable in pairs
  - Single part span shroud)
- Front compressor (LPC):
  - Five stages (including the fan)
- Turbine shaft coupling:
  - Located between low turbine shaft and front fan hub
- Fan cases:
  - Contain fan blade tip rubstrips
  - Has fan exit vanes and struts
  - Has ground handling pads
- Compressor intermediate case:
  - Supports No. 1 and No. 2 bearings
  - Provision for forward engine mount
  - Has variable N2 inlet guide vanes and Mach probes
- Rear compressor (HPC):
  - Eleven stages (inlet guide vanes, 5th, 6th, and 7th stage vanes are variable)
  - Drives the angle gearbox
  - 8th and 9th stage bleed ports
- Diffuser case and combustor:
  - Supports No. 3 bearing
  - Supports 20 fuel nozzles
  - 13th stage turbine cooling air ports
  - 15th stage bleed ports
  - Two igniter plug bosses
- Combustor:
  - Single annular chamber
- Rear compressor drive turbine (HPT):
  - Two-stage assembly (external case cooling)
  - Turbine cooling air ports for HPT internal cooling
- Front compressor drive turbine (LPT):
  - Four-stage assembly (external case cooling)
- Turbine exhaust case:
  - Supports No. 4 bearing
  - Supplies aft mount attach points, ground handling bracket attach points, and mounting bosses for exhaust gas pressure and temperature probes
- Angle gearbox:
  - Mounted to the intermediate case
  - Driven by HPC through the towershaft
- Main Gearbox
  - Diffuser case mounted
  - Driven by the angle gearbox through the horizontal driveshaft

Major Assemblies



CT26322

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INDICATING SYSTEM

Engine Display and Warning Indicators

GENERAL

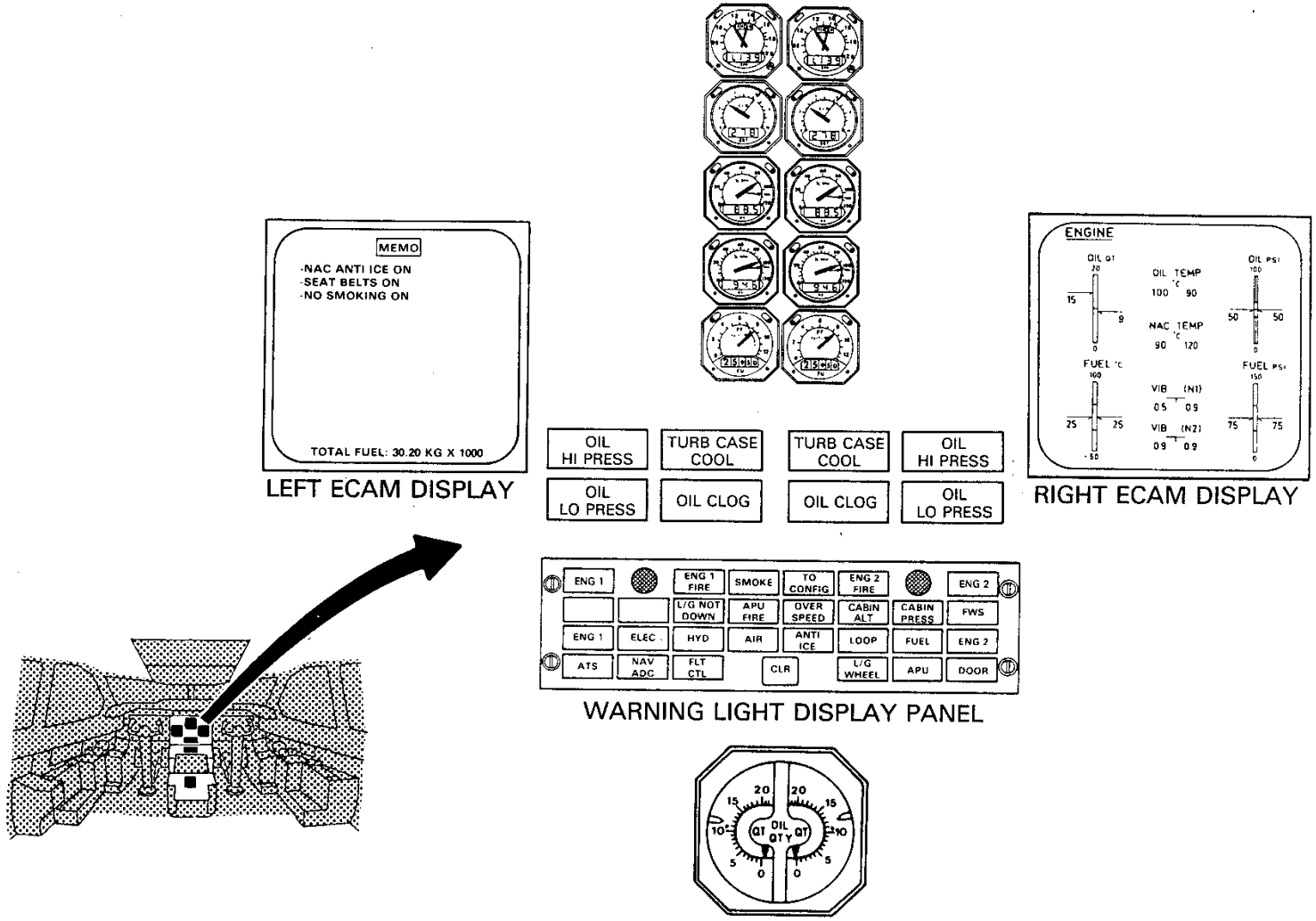
Purpose:

- The indicating system is used to sense, transmit, and display engine performance and mechanical operating parameters.

Description and Operation:

- Engine operating parameters
  - Performance
    - Engine pressure ratio - EPR
    - Low rotor speed - N1 in percent
    - High rotor speed - N2 in percent
    - Exhaust gas temperature - EGT ^{o}C
    - Fuel flow - Kg/hr or lbs/hr
  - Mechanical
    - Vibration - non-dimensional units
- System / Component Status
  - Oil filter ΔP
  - Oil pressure - psi
  - Oil temperature - ^{o}C
  - Oil quantity - quarts
  - Fuel pressure - psi
  - Fuel temperature - ^{o}C
- Displays / Indicators
  - Analog gages
  - ECAM CRTs
  - Caution lights
  - Warning lights
  - Audible signals

Engine Display and Warning Indicators



CT4042.19971009

CT4042

Engine Indicating Systems - Engine Operating Parameters

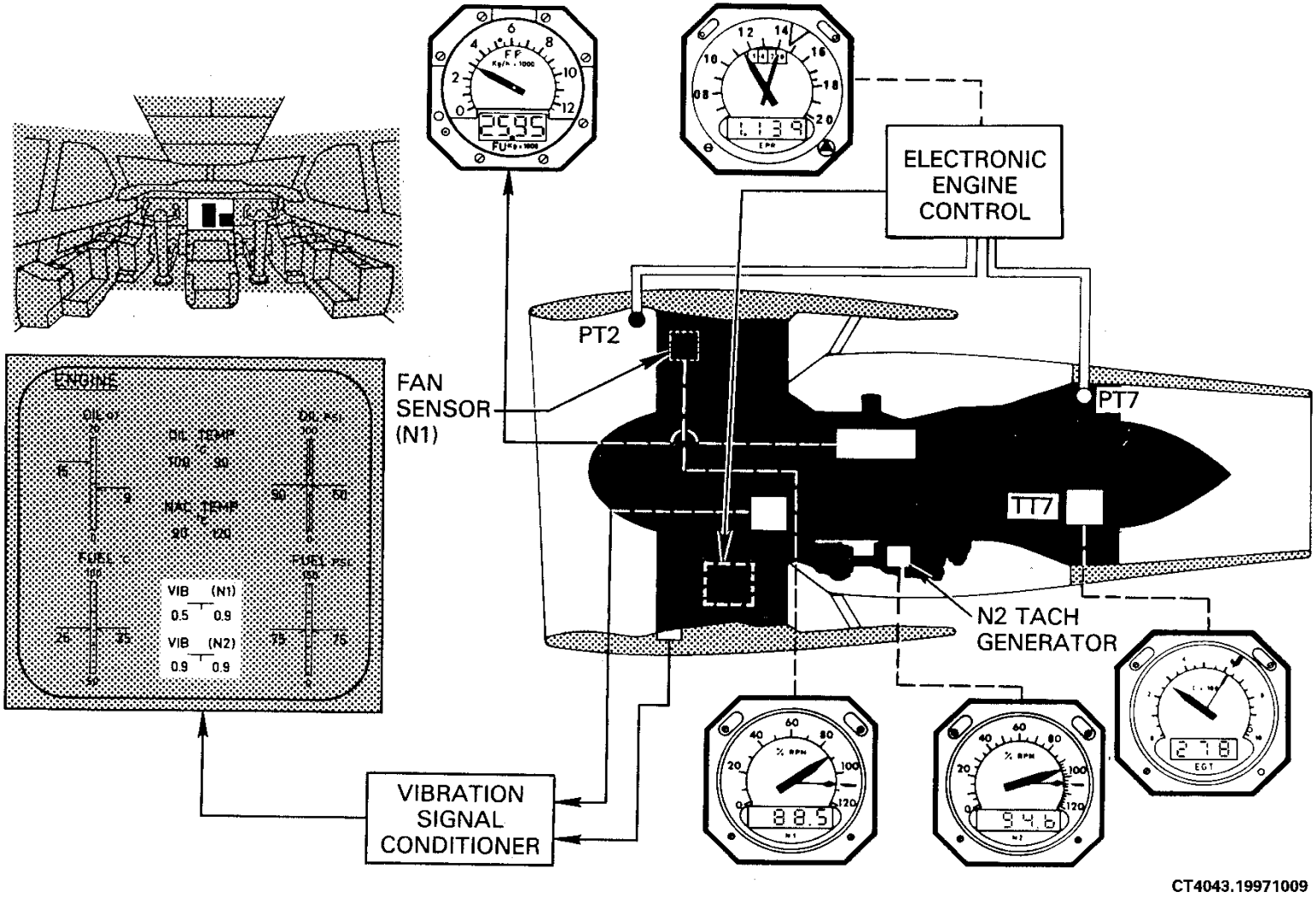
GENERAL

Purpose:

- The indicating system is used to sense and indicate (in specific units) the following engine operating parameters.

PARAMETER	TRANSMITTER(S)	INDICATOR
Fuel Flow	Fuel flowmeter	Analog - digital
Engine pressure ratio (EPR)	PT2 probe (1); PT7 probes (6) through EEC	Analog - digital
Low rotor speed (N1)	N1 speed sensor	Analog - digital
High rotor speed (N2)	N2 tachometer generator	Analog - digital
Exhaust gas temperature (EGT)	TT7 probes (6 averaged)	Analog - digital
Engine vibration	Accelerometer	Right ECAM - CRT

Engine Indicating Systems



CT4043

EPR Probes and Indicator

Purpose:

- The EPR engine operating parameter gives indication of the actual engine pressure ratio (PT7 / PT2) for thrust setting and engine performance monitoring.

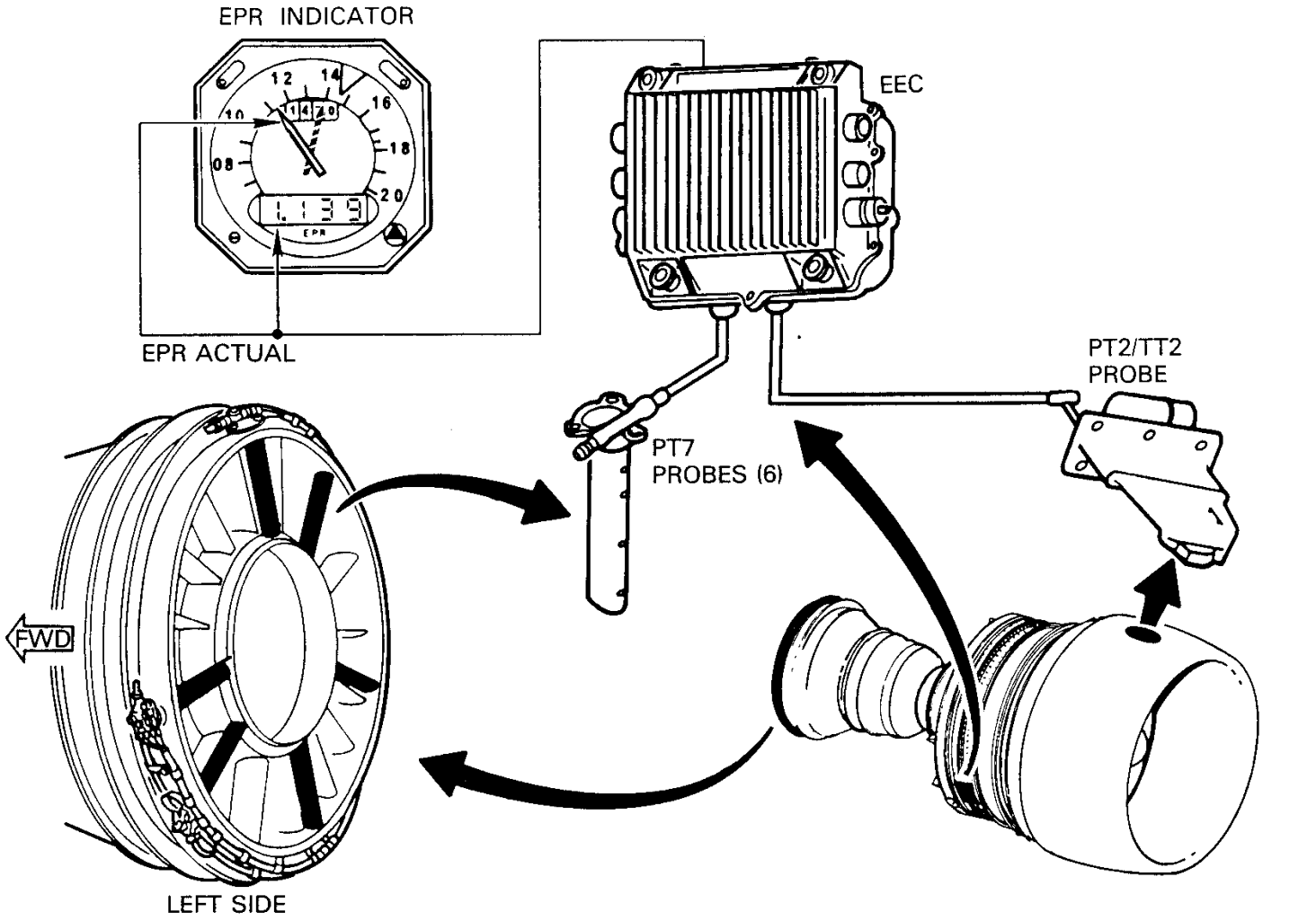
Components:

- PT7 probes (6)
  - Found in the turbine exhaust case
- PT2 probe (1)
  - Found on the inlet cowl at the 12:30 position
- Electronic engine control (EEC)
  - Found on the fan case at the 5:00 position
- Engine pressure ratio (EPR) indicator
  - Found on the cockpit center instrument panel

Description and Operation:

- PT2 probe senses the pressure of the inlet air stream (combination PT2 / TT2 probe)
- PT7 probes sense the pressure of the exhaust gas stream just aft of the last turbine stage (combination PT7 / TT7 probes)
- The two pressure signals are delivered to the EEC
- The EEC converts the pressure signals to an electrical signal which gives the actual EPR indication
- Indicator is analog - digital repeat
  - Range 0.65 to 2.0 EPR units
- Indicator gives three EPR readouts
  - EPR actual
    - White pointer
    - Digital repeat
  - EPR command
    - Striped pointer
  - EPR limit
    - Index
    - Digital repeat - manual mode
- Push to test (BITE)
  - Push PUSH TO TEST BUTTON will cause EPR actual (pointer and digital) to go to 1.75
- EPR index (manual set)
  - Pull out EPR index manual set knob
    - Removes mask from the EPR index digital display
    - By rotating knob, EPR index bug will change position and reading in EPR index window will change

EPR Probes and Indicator



CT4044

EGT Probes and Indicator

Purpose:

- The EGT engine operating parameter gives an averaged exhaust gas temperature indication in ^{o}C.

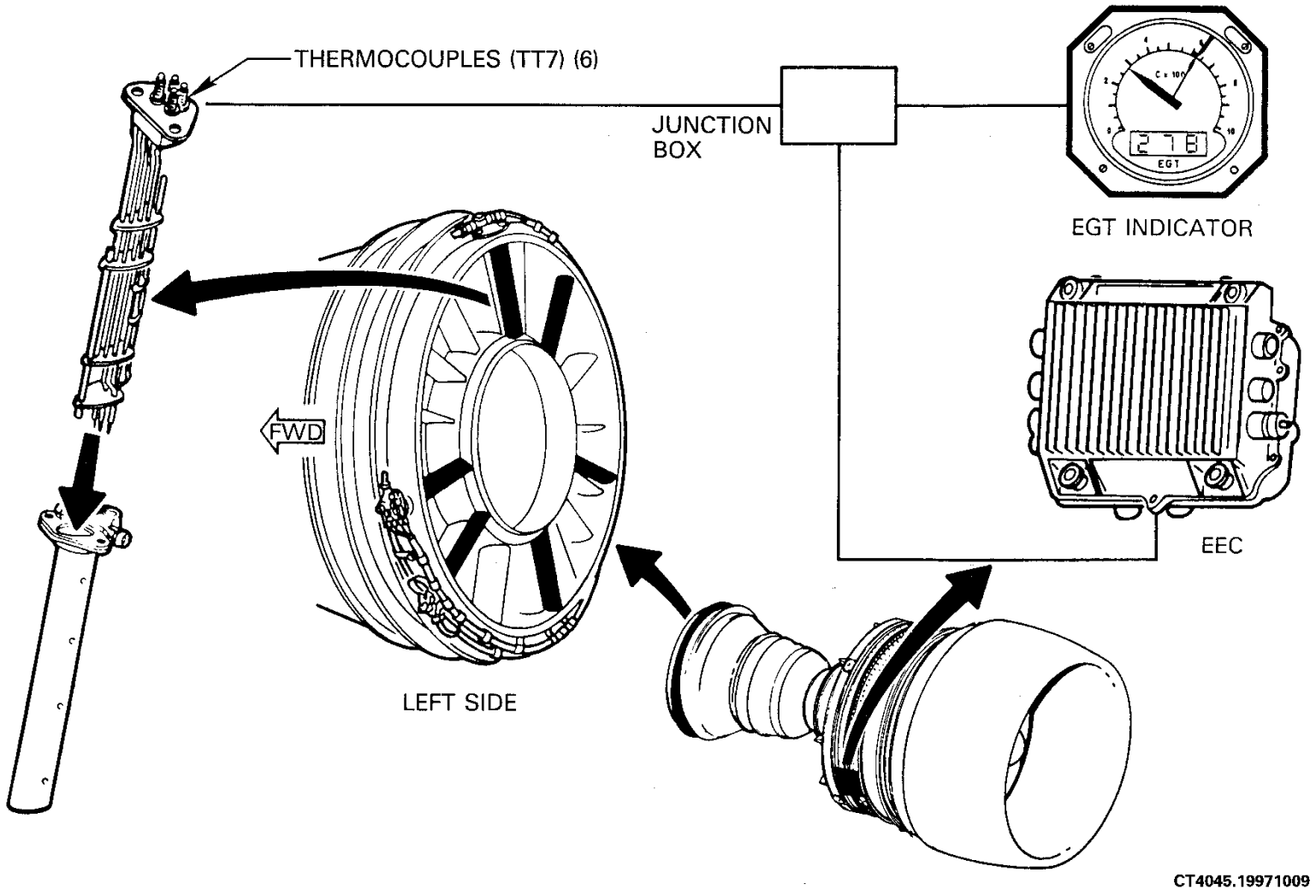
Components:

- TT7 probes (6)
  - Combination PT7 / TT7 probes found in the turbine exhaust case
- Junction box
  - Found on the turbine exhaust case at the 5:30 position
- Electronic engine control (EEC)
  - Found on the fan case at the 5:00 position
- Exhaust gas temperature (EGT) indicator
  - Found on the cockpit center instrument panel

Description and Operation:

- TT7 probes each contain two sets of chromel / alumel (CR-AL) junctions
  - One set is harnessed together in the junction box to give an averaged TT7 output signal to the EGT indicator
  - Second set is harnessed together in the junction box to give an averaged TT7 output signal to the EEC
- Indicator is analog - digital repeat
  - Range: 0 to 1000 ^{o}C
  - Redline limit = _____ ^{o}C

EGT Probes and Indicator



CT4045

N1 Speed Sensor and Indicator

Purpose:

- The N1 speed engine operating parameter gives an indication of low rotor speed (N1) in percent (100% N1 = 3600 RPM).

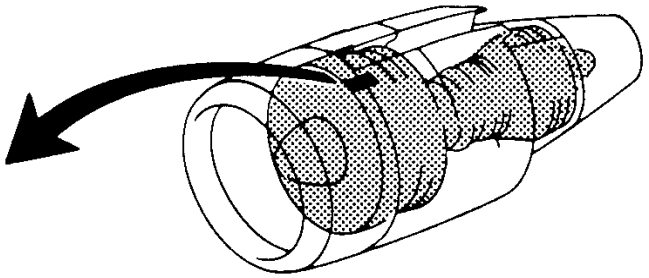
Components:

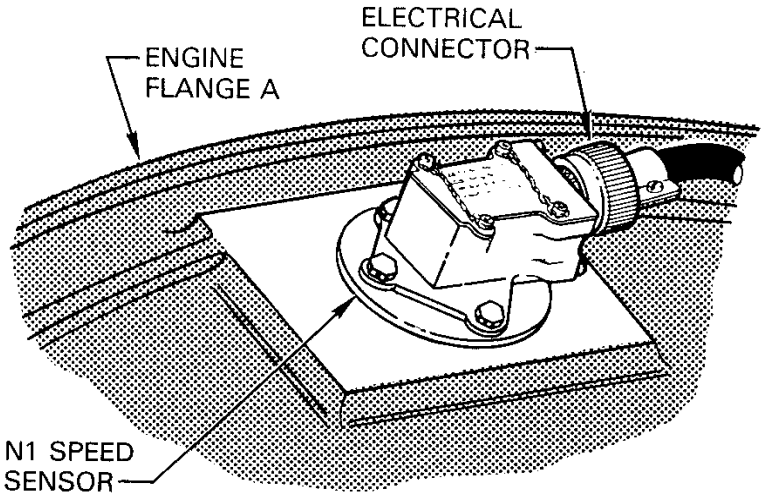
- N1 speed sensor
  - Found on the fan case at the 1:00 position
- N1 speed indicator
  - Found on the cockpit center instrument panel

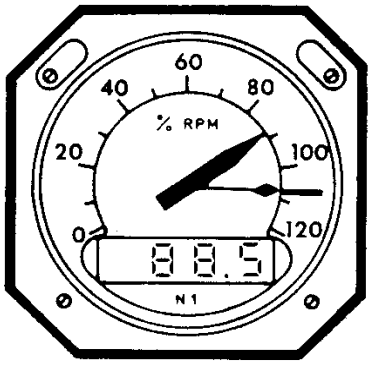
Description and Operation:

- Speed sensor is magnetic pulse counter indicating the rate of fan blade passage
- Indicator is analog - digital repeat
  - Range: 0 to 120%
  - Overspeed pointer
  - Redline limit = _____ %

N1 Speed Sensor and Indicator







CT4046.19971009

CT4046

N2 Transmitter and Indicator

Purpose:

- The N2 speed engine operating parameter gives an indication of high rotor speed (N2) in percent (100% N2 = 7807 RPM).

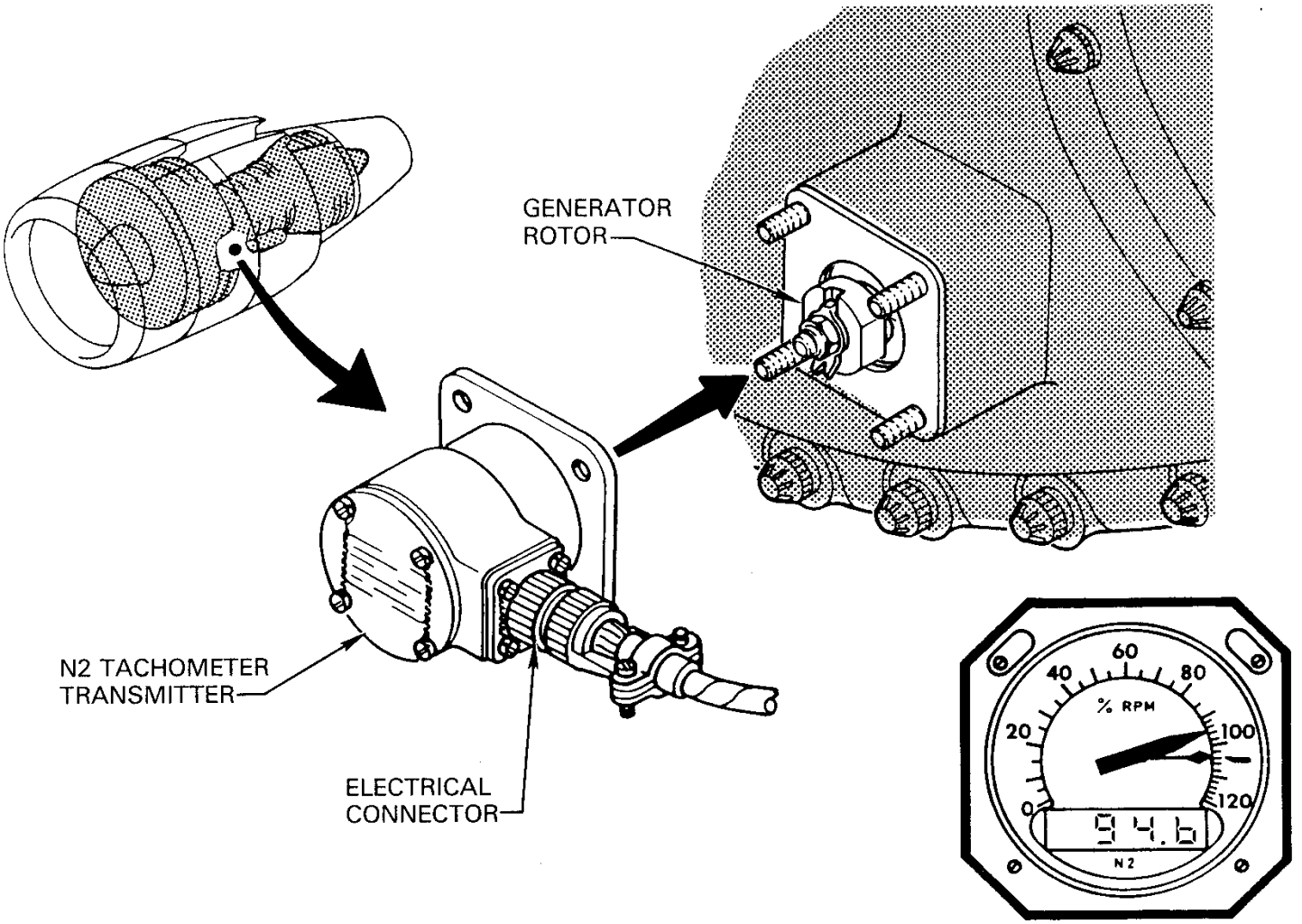
Components:

- N2 tachometer generator (transmitter)
  - Found on the front of the main gearbox
- N2 speed indicator
  - Found on the cockpit center instrument panel

Description and Operation:

- Transmitter is magnetic frequency generator with separate rotor and stator
- Indicator is analog - digital repeat
  - Range: 0 to 120%
  - Overspeed pointer
  - Redline limit = _____ %

N2 Transmitter and Indicator



CT4047.19971009

CT4047

Vibration Accelerometer and Display

Purpose:

- The vibration operating parameter gives vibration indication for monitoring mechanical abnormalities.

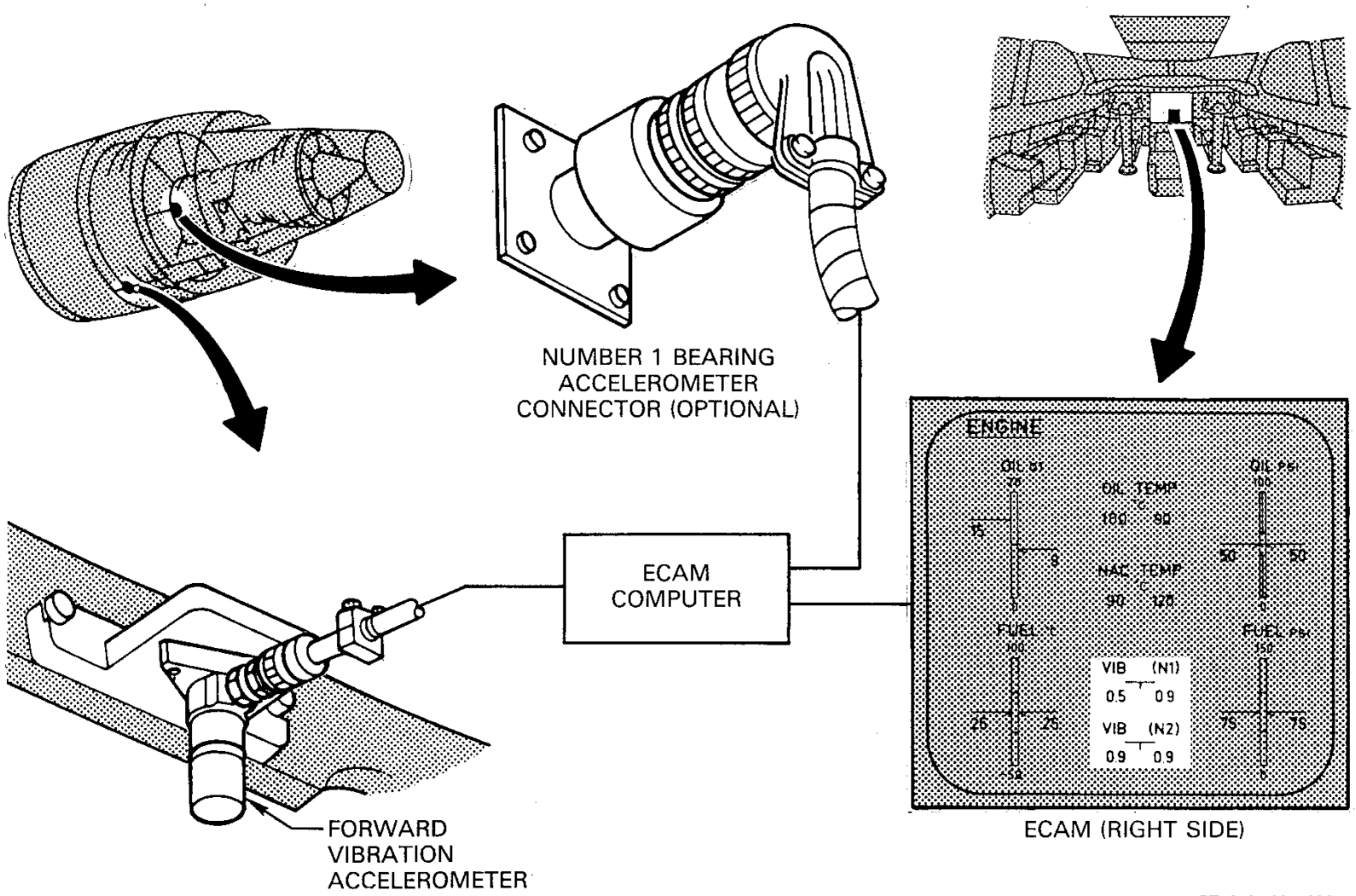
Components:

- Forward vibration accelerometer
  - Found on the fan case at the 6:00 position
- No. 1 bearing accelerometer (optional)
  - Found on the No. 1 bearing support
  - Electrical connector on the intermediate case at the 8:00 position
- Right ECAM display
  - Found on the right side of the center display panel

Description and Operation:

- Accelerometers generate a voltage (piezo-electric) proportional to the high and low vibration
- Voltage signal is sent to the ECAM computer for amplification / conversion to supply ECAM CRT display
- Vibration readout is displayed on the engine and cruise pages on the right ECAM in non-dimensional units
  - Range: 1-10
  - Indication flashes if above 4 units

Vibration Accelerometer and Display



CT4049.19971009

CT4049

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FUEL DISTRIBUTION SYSTEM

Fuel Distribution System

GENERAL

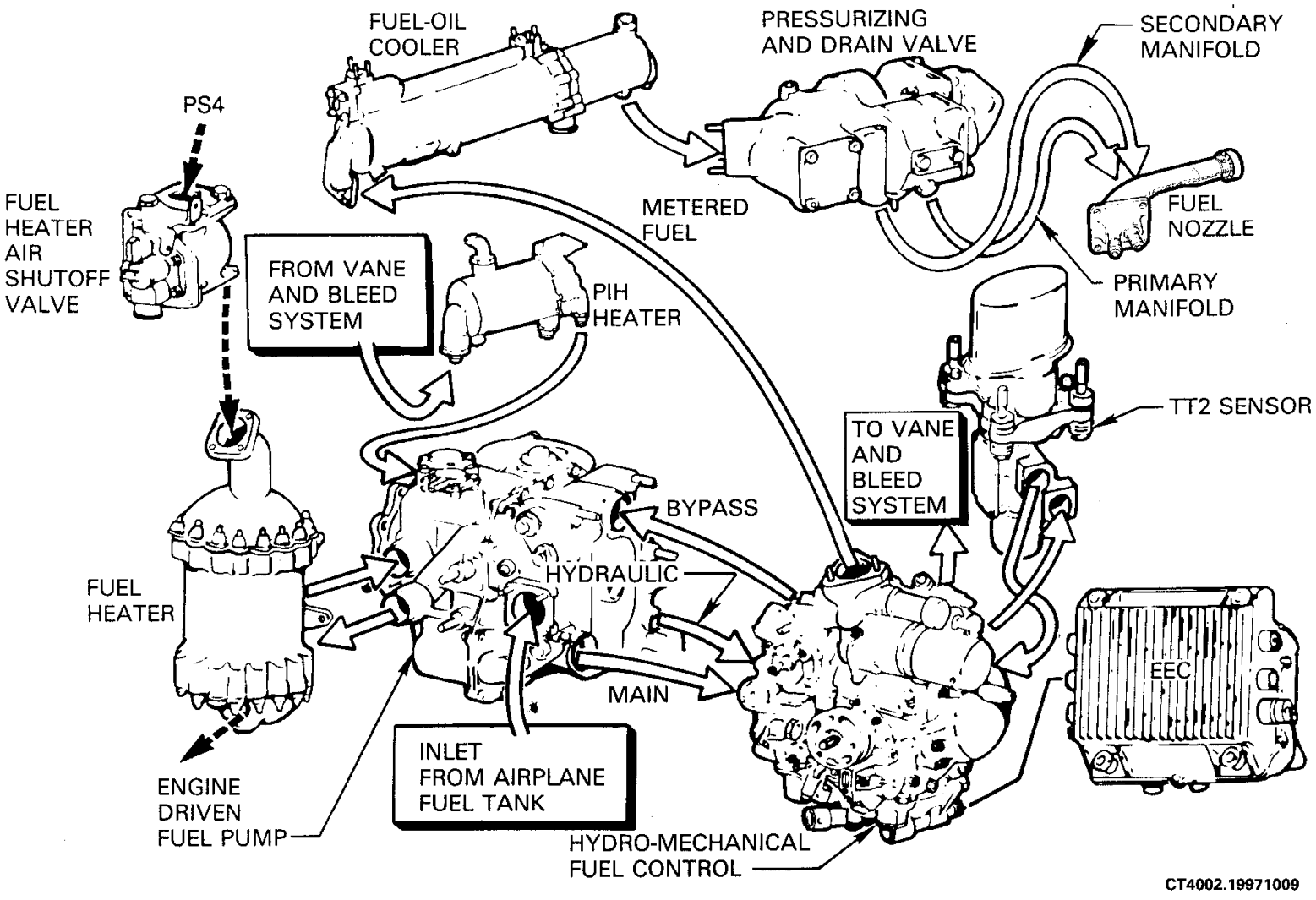
Purpose:

- The fuel system supplies pressurized metered fuel for combustion and pressure regulated fuel to the compressor airflow control system.

Components:

- Engine-driven fuel pump
- Fuel heater
- Fuel heater air shutoff valve
- Hydromechanical fuel control (HMC)
- TT2 sensor
- Fuel / oil cooler
- Pressurizing and drain valve (P&DV)
- Fuel manifolds and nozzles
- PIH heater / IDG oil cooler
- Electronic engine control

Engine Fuel System Components

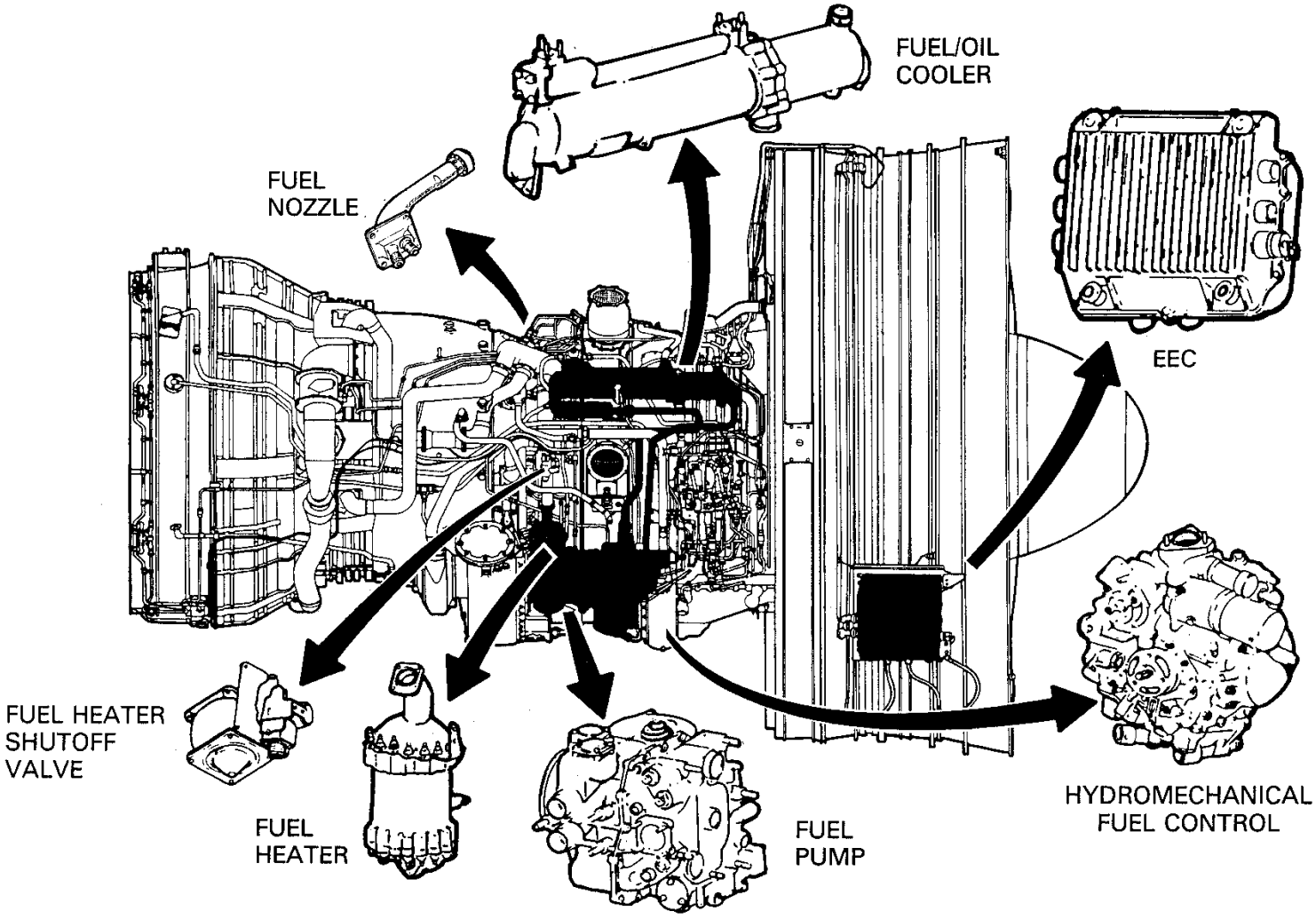


CT4002

Engine Components - Right Side

- Engine-driven fuel pump
  - Mounted on the right front side of the main gearbox
- Hydromechanical fuel control
  - Mounted on the front face of the fuel pump
- Fuel heater
  - Attached to the outboard side of the fuel pump
- Fuel heater shutoff valve
  - Mounted above the heater in the 15th stage air duct at the 3:30 position
- Fuel / oil cooler
  - Mounted on the HPC case at the 2:30 position
- Electronic engine control
  - Mounted on the fan case at the 5:00 position
- Fuel manifolds
  - Mounted 360^{o} around the diffuser case
- Fuel nozzles
  - Equally spaced around the diffuser case and extend into the combustion chamber

Fuel System - Right Side

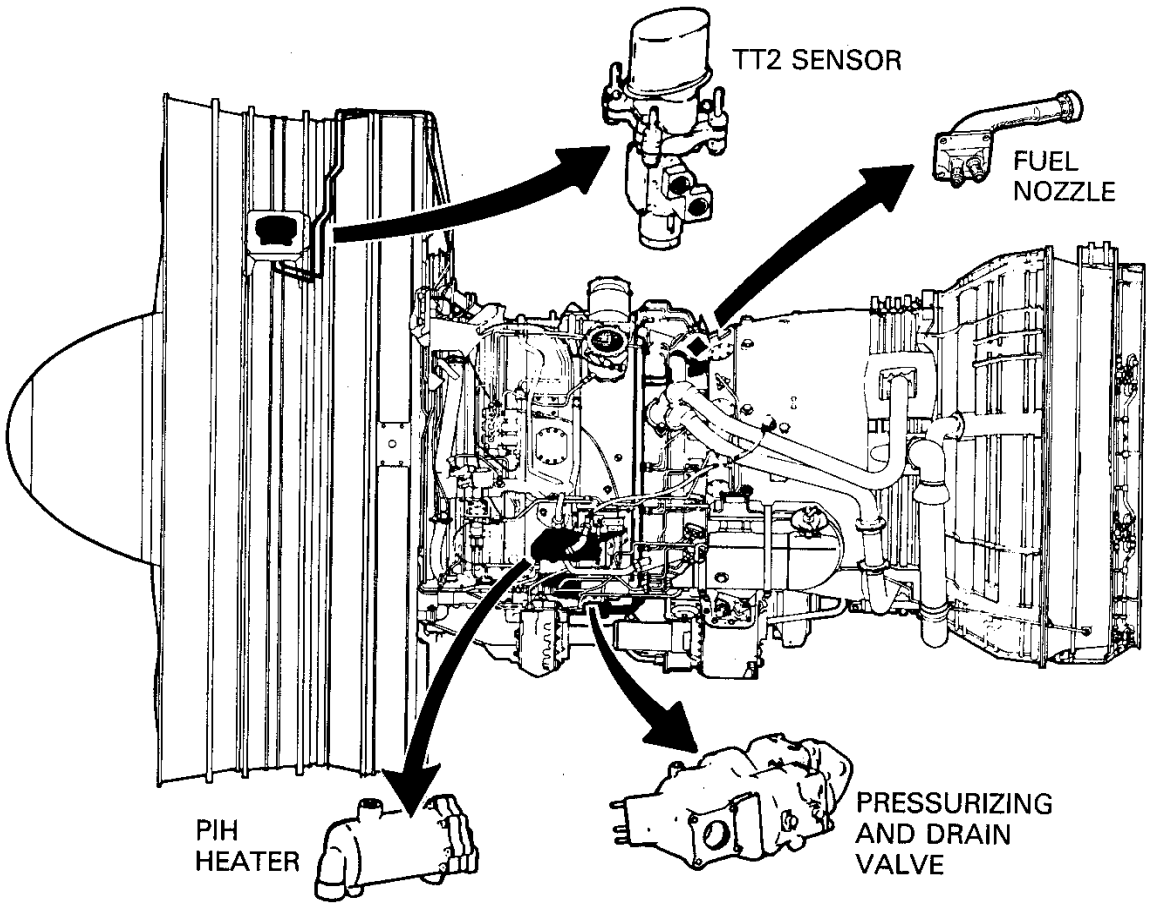


CT4066

Engine Components - Left Side

- TT2 sensor
  - Mounted on the fan case at the 11:00 position
- PIH heater
  - Mounted on the HPC case at the 8:00 position
- Pressurizing and drain valve
  - Mounted on the HPC case at the 6:00 position
- Fuel manifolds
  - Mounted 360° around the diffuser case
- Fuel nozzles
  - Equally spaced around the diffuser case and extend into the combustion chamber

Fuel System - Left Side



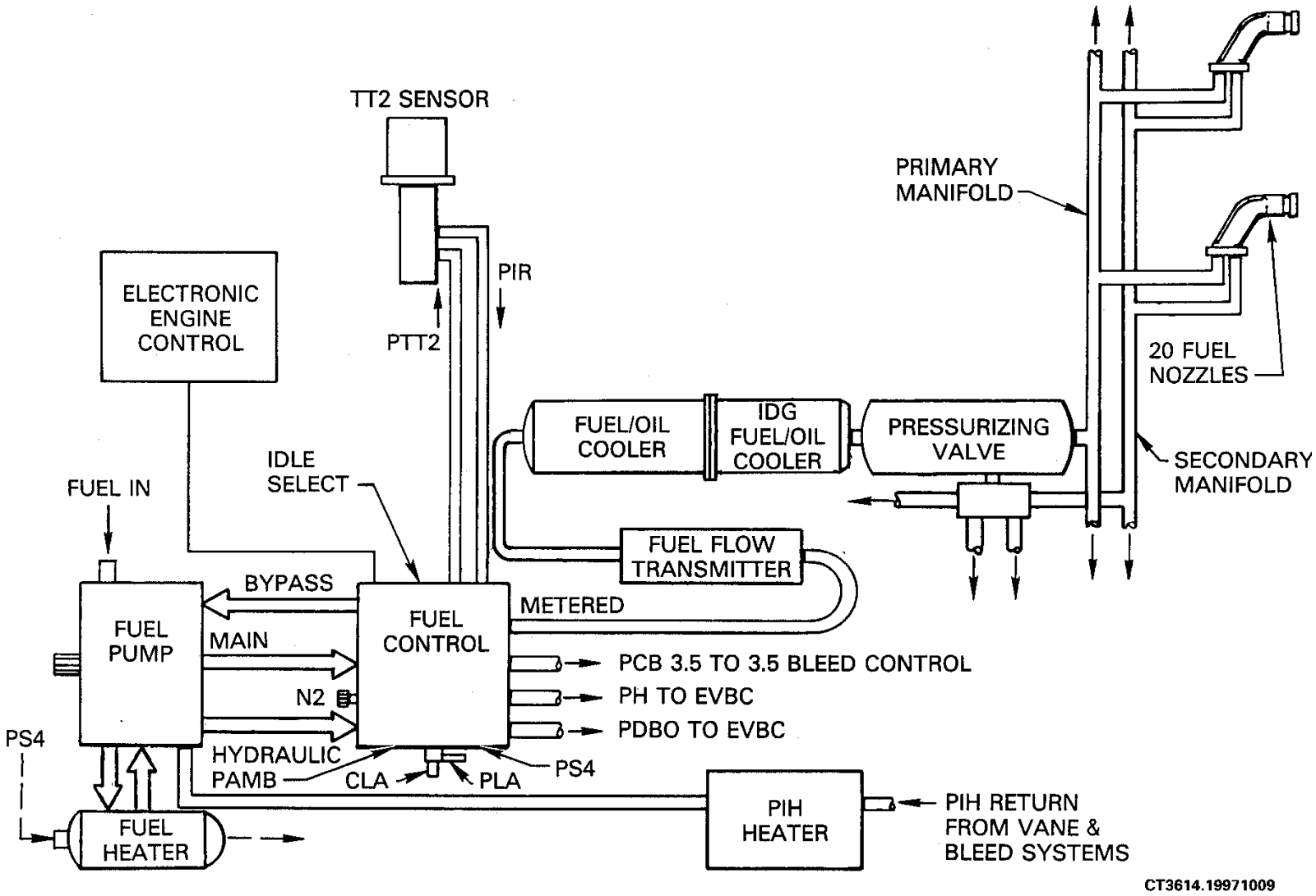
CT4067.19971009

CT4067

Fuel Flow Sequence

- Fuel for combustion is supplied to the engine-driven fuel pump by aircraft-mounted fuel boost pumps. This fuel's pressure is increased by the impeller stage of the engine-driven pump and is sent through the fuel heater. The fuel heater uses 15th stage air to heat the fuel. The fuel then returns to the pump, passes through an internal filter and is sent to the pump's hydraulic gear stage and the main gear stage. (The pump also uses the usual bypass and pressure relief valves.)
- Main gear stage
  - Main gear stage pressure is sent to the fuel control where it is metered. The excess fuel is bypassed back to the fuel pump. Metered fuel leaves the fuel control and passes through the fuel flow transmitter, fuel / oil cooler and to the pressurizing and drain valve. Here, fuel is sent into the primary and secondary fuel manifolds for distribution to the fuel nozzles. The 20 fuel nozzles atomize the fuel for combustion.
  - **Note:** Details on fuel metering will be covered later in this section.
- Hydraulic gear stage
  - Regulated hydraulic gear stage fuel pressure is used for control and actuation of the compressor bleed and variable vane systems. This fuel pressure is regulated by the fuel control and is sent to the bleed and variable vane systems as either muscle pressure or signal pressure. Return flow from these systems is routed to main fuel pump interstage.

Fuel System Schematic



CT3614

Fuel Pump

Purpose:

- The fuel pump supplies pressurized fuel to the hydromechanical fuel control for metering, as well as regulation and distribution to bleeds and vanes systems.

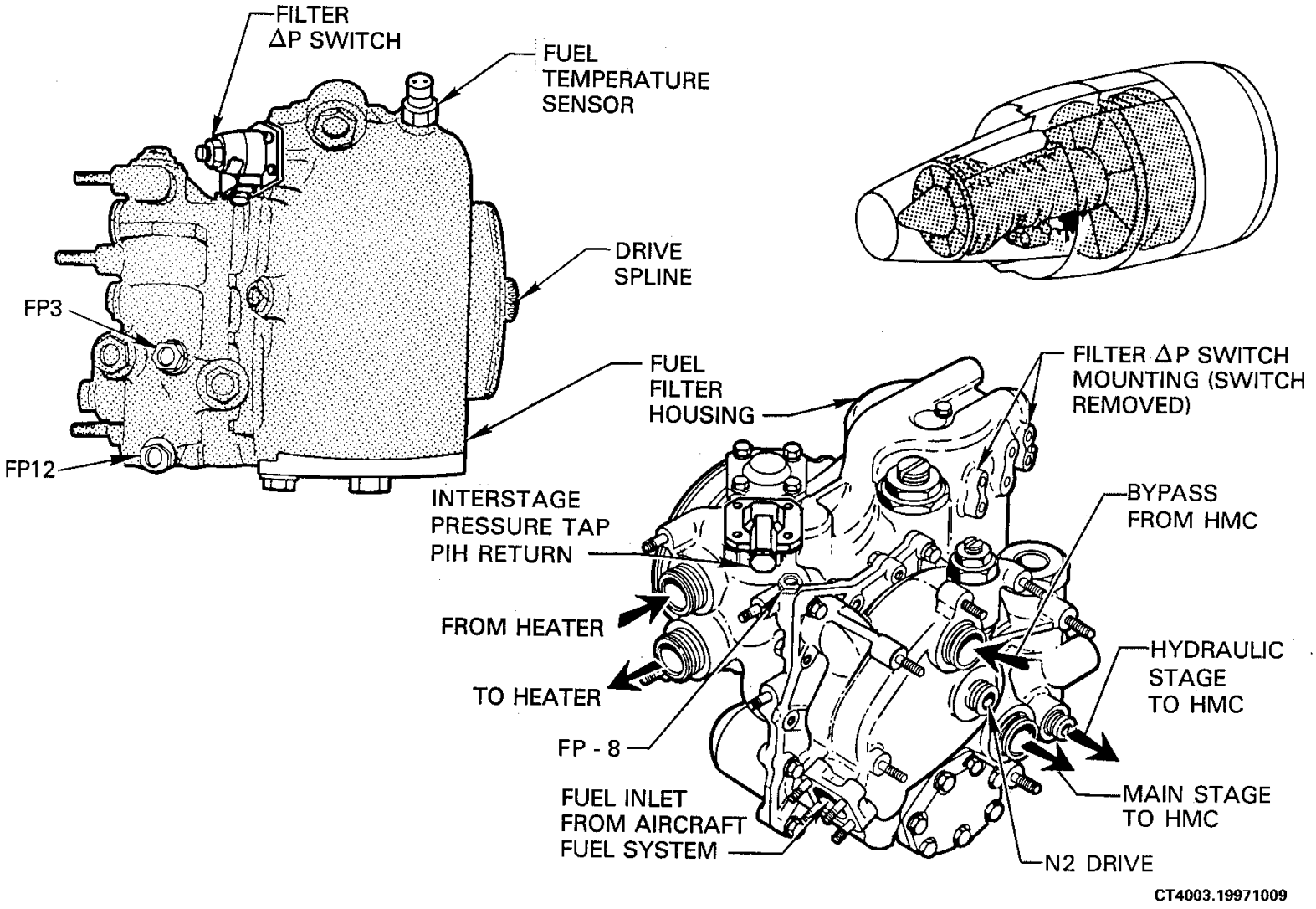
Location:

- The fuel pump is mounted on the right front drive pad of the main gearbox.

Description and Operation:

- Secured to the gearbox by a QAD ring
- Has three pumping elements
  - Boost (impeller)
  - Main (gear)
  - Hydraulic (gear)
- Inputs
  - Fuel from the aircraft fuel system boost pumps
  - Fuel control bypass fuel
  - Return from fuel heater
  - PIH
  - Power from gearbox
- Outputs
  - Boost stage pressure to fuel heater
  - Main stage discharge to fuel control unit
  - Hydraulic stage discharge to fuel control unit
- Significant features
  - 40 micron interstage filter
  - Hydraulic stage transfer valve
  - Bypass valves for boost stage, fuel heater, and fuel filter
  - Relief valves for main and hydraulic stages
  - Filter differential pressure switch
  - Fuel temperature probe (interstage FT1 port)
  - Fuel pump interstage pressure tap (FP8 port)
    - Pressure indication displayed on right ECAM display (engine pages)
  - Troubleshooting pressure taps
    - FP3 (main stage)
    - FP12 (hydraulic stage)

Fuel Pump



CT4003

Fuel Heater and Components

FUEL HEATER

Purpose:

- The fuel heater supplies heated fuel to prevent ice formation on the fuel filter, differential pressure switch, and the hydromechanical fuel control servos.

Location:

- The fuel heater is installed on the outboard side of the fuel pump..

Description and Operation:

- Single pass heat exchanger
- Uses 15th stage air to heat fuel
- Fuel heater bypass valve in fuel pump assembly
- Has drain plug
- Normal duty cycle: 1 minute ON; 30 minutes OFF

FUEL HEATER AND SHUTOFF VALVE

Purpose:

- The fuel heater air shutoff valve controls the flow of 15th stage air to the fuel heater.

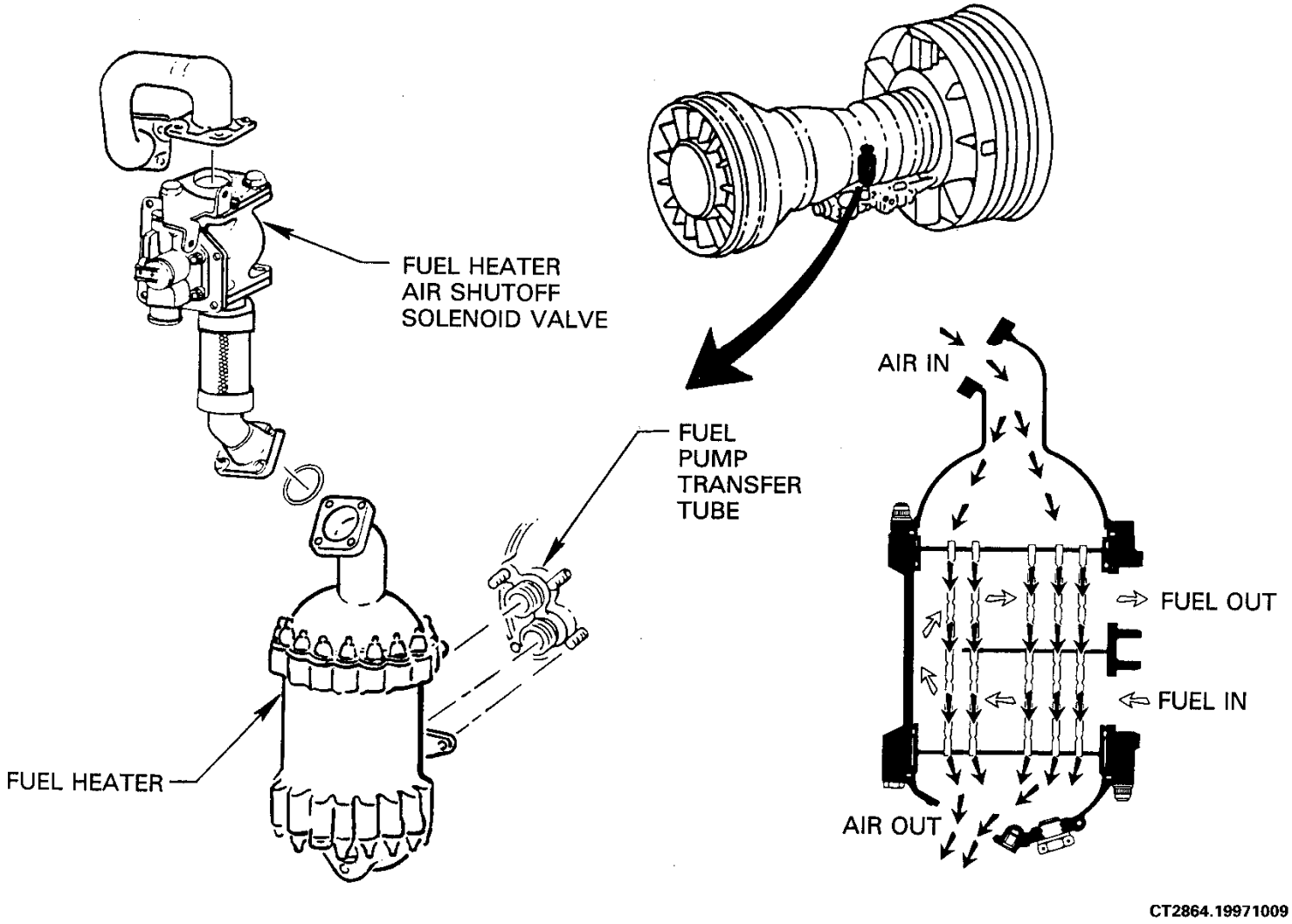
Location:

- The fuel heater air shutoff valve is located on the HPC case at the 3:30 position.

Description and Operation:

- Two position
- Electrically controlled - pneumatically actuated
- Controlled from fuel heat management panel
- Visual position indicator
- Fan air cooled

Fuel Heater and Components



CT2864

Fuel Temperature and Differential Pressure (ÄP) Indication and Control

GENERAL

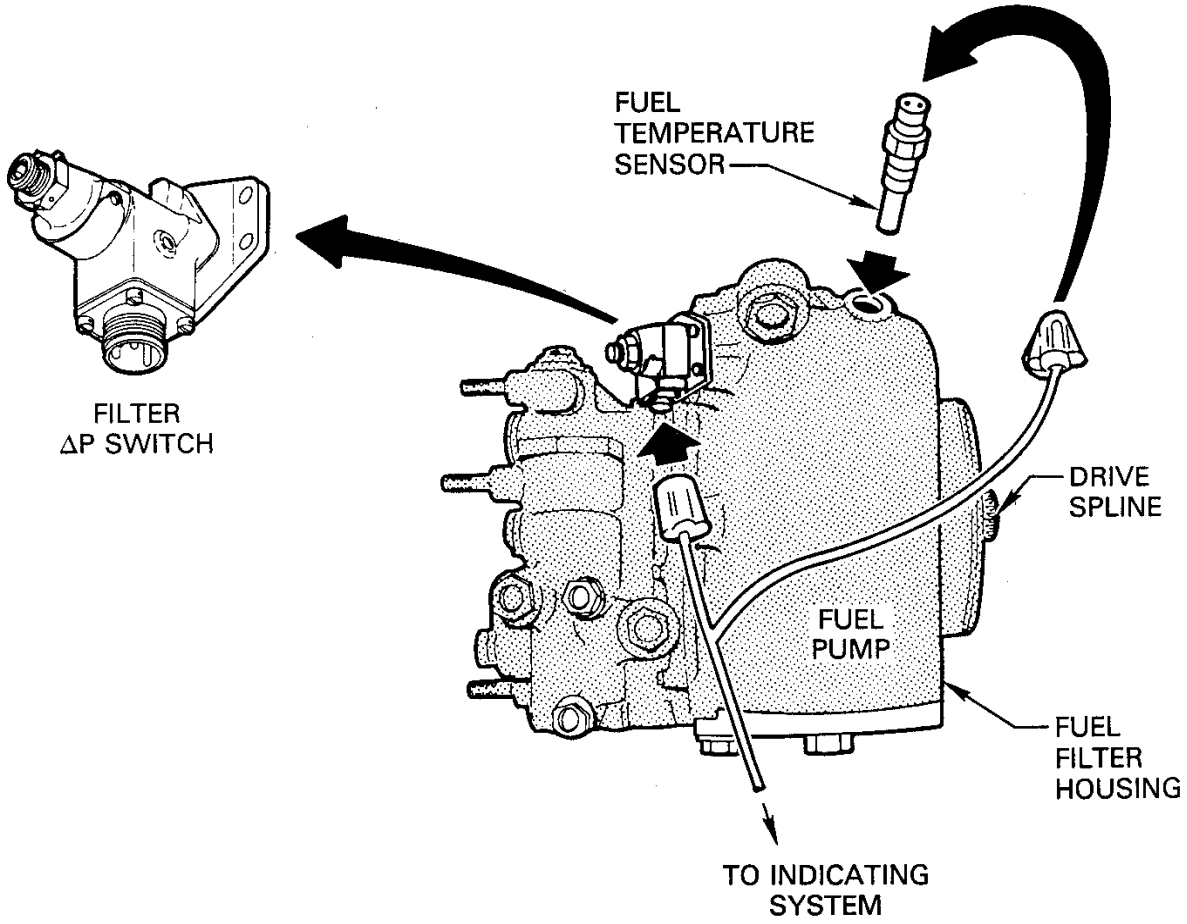
Purpose:

- Sensors are used to give temperature indication, threshold temperature signal for fuel heat selection in the automatic mode, and fuel filter ∆ pressure indication.

Components:

- Fuel temperature indication
  - Displayed in lower left quadrant of engine page on right ECAM CRT
  - Indication also given on dual analog indicator on fuel heater control panel found on the center overhead panel
- Temperature sensor bulb
  - Located in the fuel pump's FT1 port (pump interstage after fuel filter)
- Fuel filter ∆P switch
  - Controls filter light on fuel heater control panel (amber)
  - Mounted on the fuel pump filter housing
  - Closes at 4.8 to 6.2 psid (increasing)
  - Opens at 2.5 to 4.5 psid (decreasing)

Fuel Temperature and Filter ÄP Sensors



CT4068.19971009

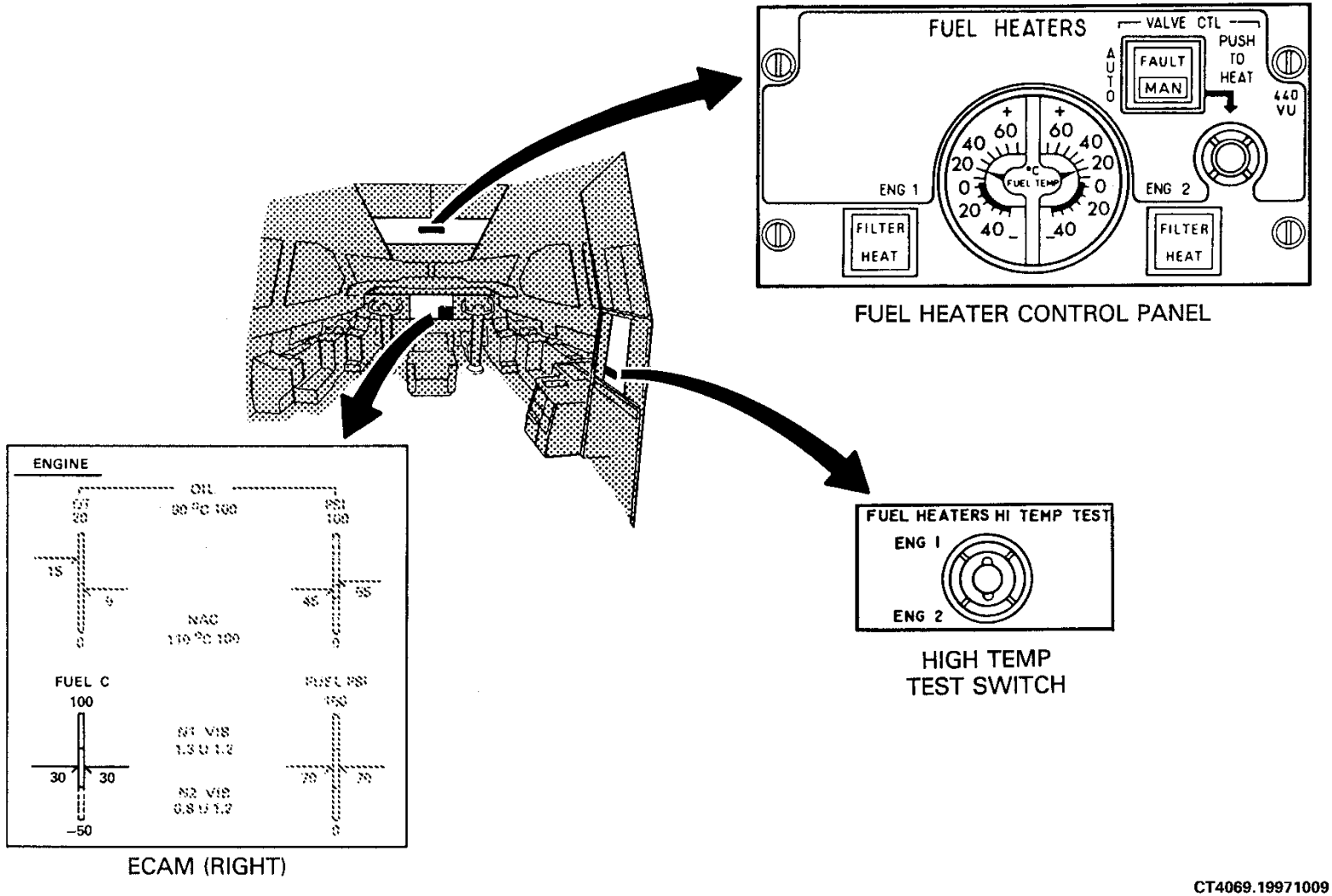
CT4068

Fuel Temperature and Differential Pressure (ÄP) Indication and Control

Description and Operation:

- Resistance-type probe is immersed in pump interstage fuel flow
- Fuel temperature signal is directed to the ECAM computer for display on the right ECAM (engine page)
  - Range: -50°C to +100°C
- Analog display on fuel heater control panel
  - Range: -40°C to +60°C
- Fuel heater control panel
  - Push button VALVE CTL (control) selects automatic or manual mode
    - AUTO (switch pushed in)
      - Heat automatically selected for short intervals when fuel temperature drops below 0°C (1 minute) and -10°C (2.5 minutes). Amber light indicates system fault
    - MANUAL (switch out)
      - White MAN light ON and heat is selected by pushing PUSH TO HEAT button - heater valve opens for 1 minute
  - FILTER legend (amber) means the filter ΔP exceeded 4.8 to 6.2 psid
  - HEAT legend (blue) means the heater valve is open
- HI TEMP TEST switch
  - Two position (ENG1 and ENG2) on maintenance test panel used to test auto mode
  - Amber fault light illuminates if system tests pass
  - Simulates fuel temperature of 58°C with fuel heater shutoff valve open

Fuel Temperature Indication and Control



CT4069.19971009

CT4069

Throttle Control and Actuator

THROTTLE CONTROL LEVERS

Purpose:

- The thrust control levers are used to modulate thrust and EPR in both the forward and reverse thrust modes.

Location:

- The thrust control levers are found on the flight deck's center pedestal.

Description and Operation:

- Connected to the throttle control assembly (mounted on the fuel control unit) through rods and throttle cables
  - System equipped with cable tension regulators

THROTTLE CONTROL ASSEMBLY

Purpose:

- The thrust control assembly is used to convert linear motion to rotary motion.

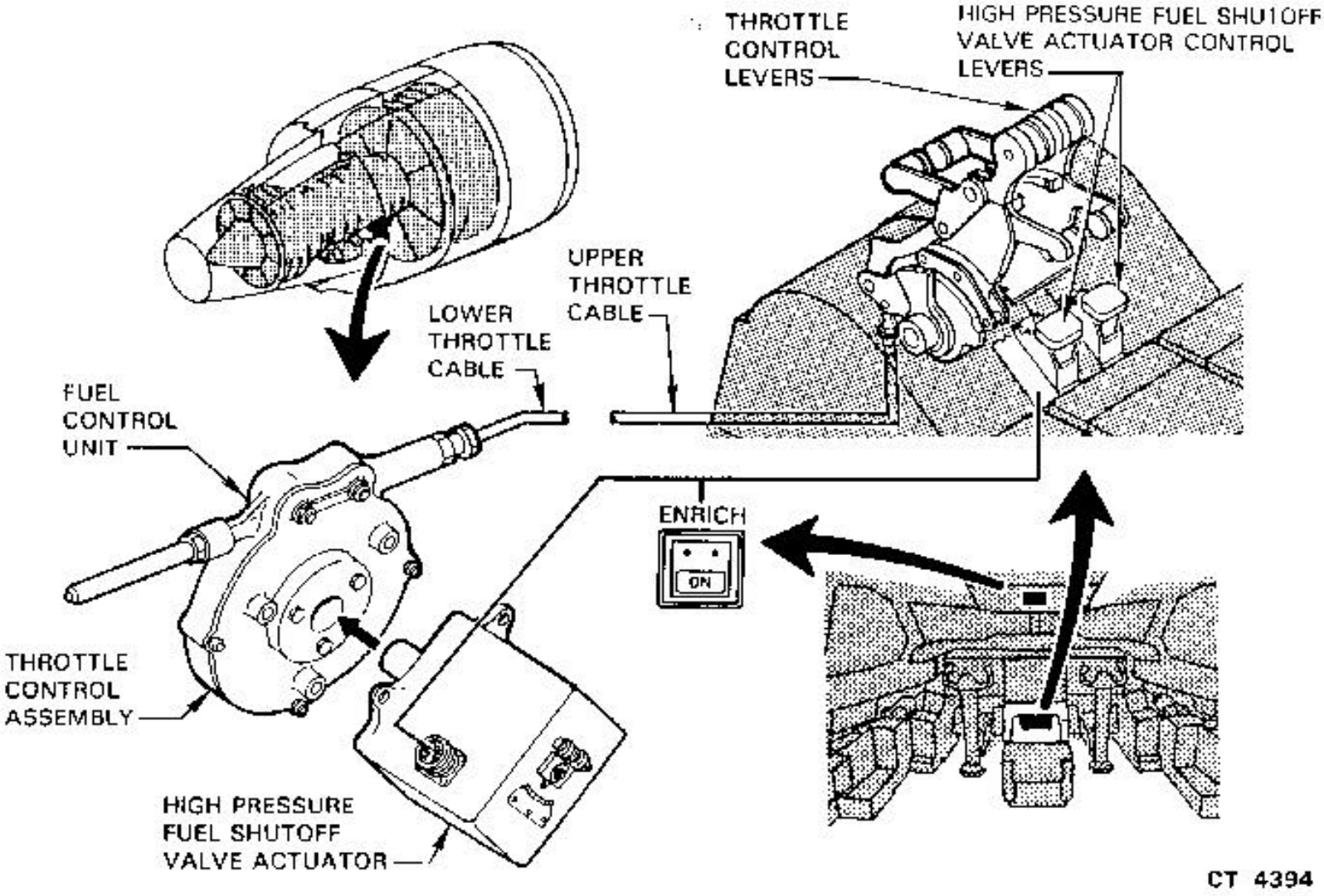
Location:

- The thrust control assembly is found on the outboard side of the fuel control unit.

Description and Operation:

- Throttle cable drives rack and pinion gear
- Rotates power lever arm to control fuel flow and thrust

Throttle Control and Actuator



CT29021

TI2 Sensor and Leak Indicator

TT2 SENSOR

Purpose:

- The TT2 sensor supplies continuous TT2 sense to the fuel control to bias:
  - Starting.
  - Acceleration and deceleration fuel scheduling.
  - Minimum and approach idle N2 speed.

Location:

- The TT2 sensor is found on the fan case at the 11:00 position.

Description and Operation:

- Has bellows and a variable orifice
- Converts differential fuel pressure to 3D cam rotation
  - Note: PTT2 and PIR tubing at the TT2 sensor is double-walled for leak detection

LEAK INDICATOR

Purpose:

- The leak indicator detects PTT2 or PIR leakage in the double-walled tubing.

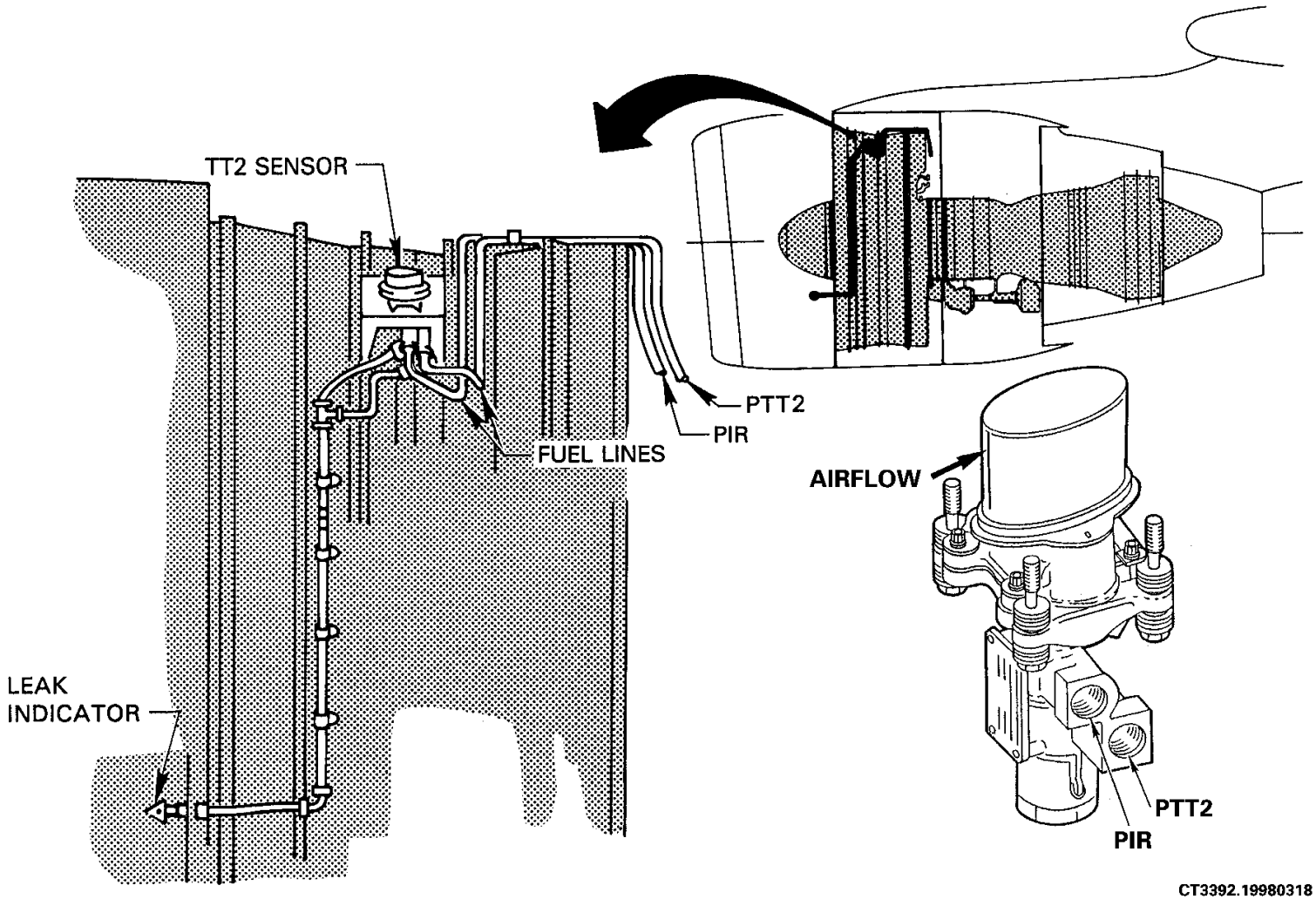
Location:

- The leak indicator is found on the inlet cowl at the 8:30 position.

Description and Operation:

- Pop-out button
- Extends at 45 psi (±5)
- Manual reset

TI2 Sensor and Leak Indicator



CT3392

Engine and IDG Fuel/Oil Coolers

ENGINE FUEL/OIL COOLER

Purpose:

- The engine fuel / oil cooler maintains engine oil temperature within operating limits.

Location:

- The engine fuel / oil cooler is found on the HPC case at the 2:30 position.

Description and Operation:

- Tubular heat exchanger
- Has an integral bypass valve, pressure and temperature taps, and a drain port
- Uses metered fuel through the fuel flow transmitter as a coolant

IDG FUEL/OIL COOLER

Purpose:

- The IDG fuel / oil cooler is the 3rd stage of the IDG oil cooling system.

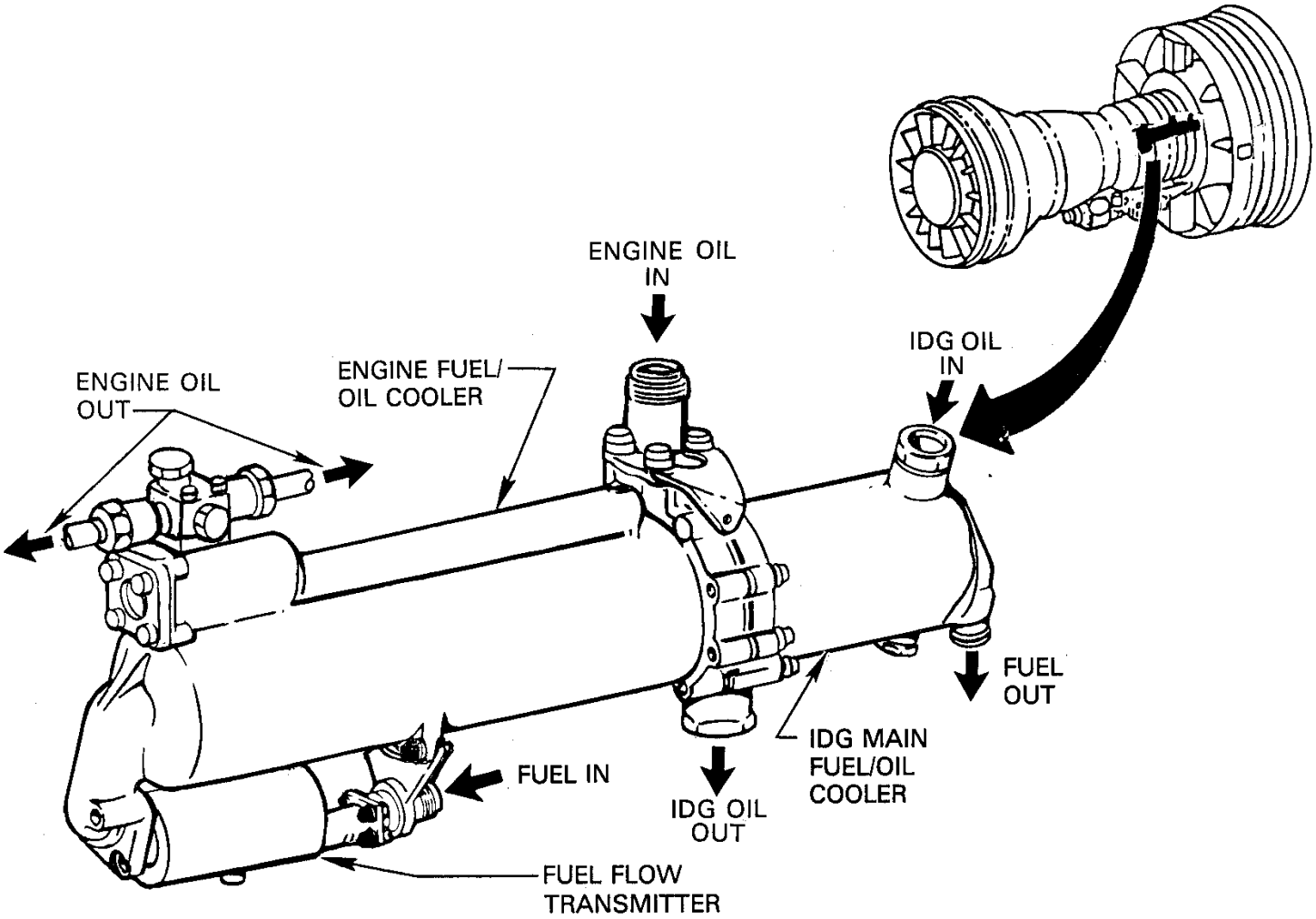
Location:

- The IDG fuel / oil cooler is found on the forward end of the engine fuel / oil cooler.

Description and Operation:

- Tubular heat exchanger
- Drain port
- Uses metered fuel as a coolant
- Engine oil and IDG oil separate

Engine and IDG Fuel/Oil Coolers



CT2993.19971009

CT2993

Fuel Pressurizing and Drain Valve

PRESSURIZING AND DRAIN VALVE

Purpose:

- The pressurizing and drain valve is used as a flow divider to schedule primary and secondary fuel.

Location:

- The pressurizing and drain valve is found on the HPC case at the 6:00 position.

Description and Operation:

- Ports
  - Inlet (metered fuel)
  - Outlet (primary)
  - Outlet (secondary)
- Inlet strainer
  - 200 mesh metal screen
  - Self-bypassing
- Drain (check) valve
  - Retains manifold and inlet line charge
  - Spring-loaded close, fuel pressure open
- Secondary pressurizing valve
  - Schedules secondary fuel
  - Spring-loaded close - assisted by PS4
  - Opened by metered fuel pressure

MANIFOLD ADAPTER

Purpose:

- The manifold adapter is used as a distributor to supply secondary fuel manifold segments.

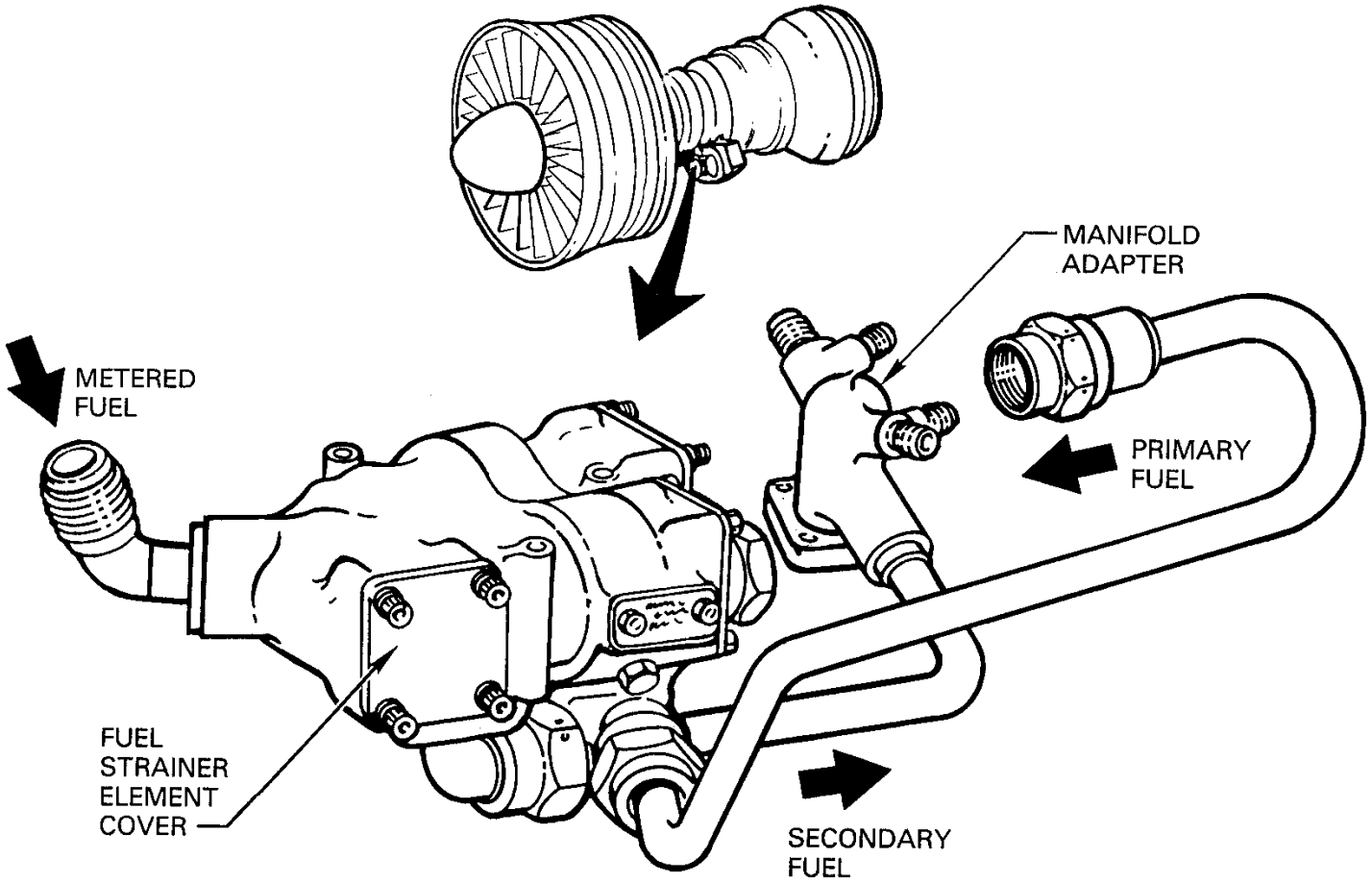
Location:

- The manifold adapter is found on the pressurizing and drain valve secondary fuel discharge tube.

Description and Operation:

- Ported manifold
- Has adapter to facilitate fuel nozzle cleaning

Fuel Pressurizing and Drain Valve



CT4071.19971009

CT4071

Fuel Nozzles

Purpose:

- The fuel nozzles supply atomized fuel for efficient combustion, low emissions, and reliable altitude relights.

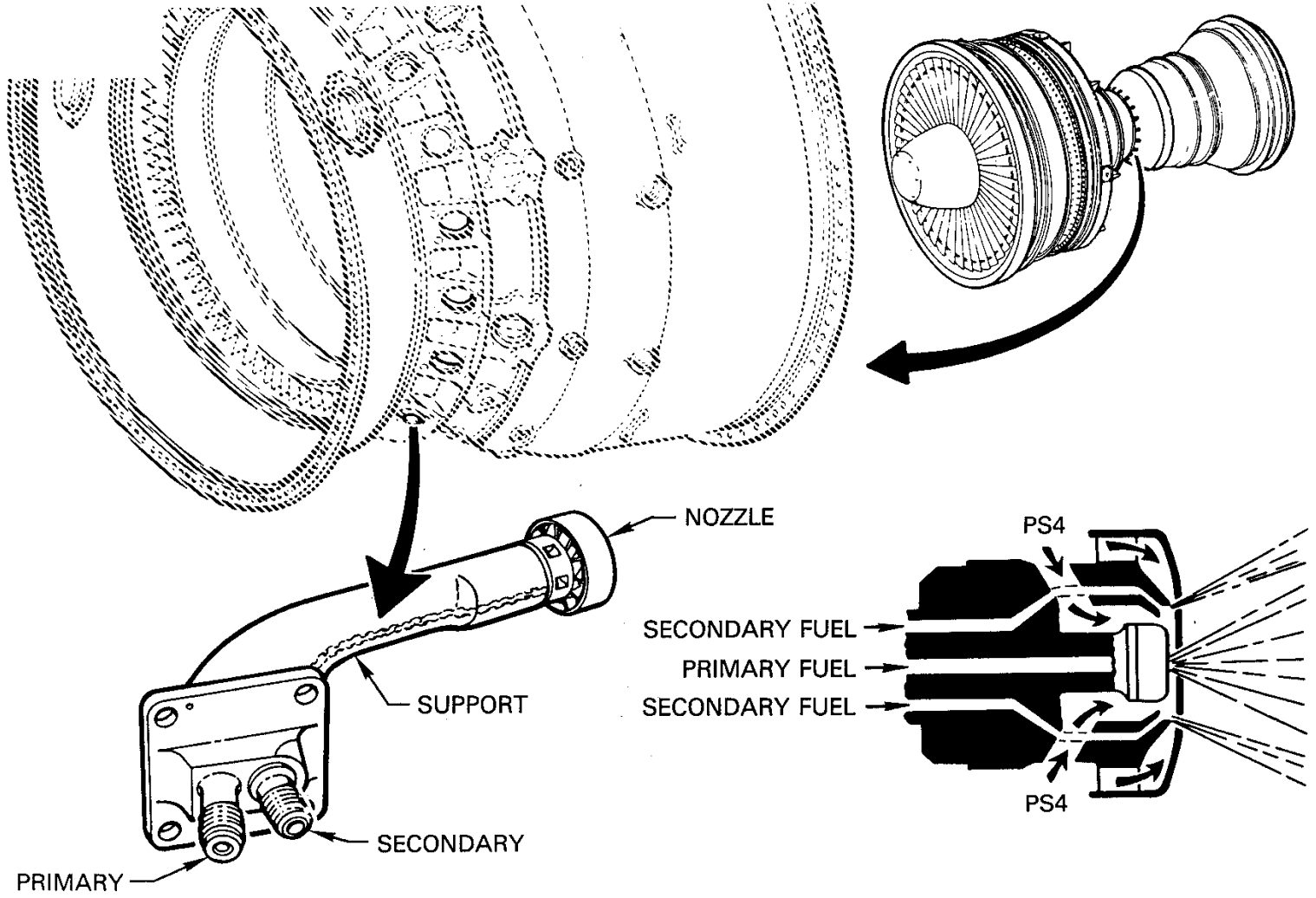
Location:

- The 20 fuel nozzles are equally spaced around the forward area of the diffuser case.

Description and Operation:

- Aerating type
- Twenty nozzles
- Dual orifice
  - Primary
  - Secondary
- Nozzles welded to support
- Nozzles at spark igniter locations flow richer to ease starting
- Remainder flow leaner due to restricted primary passages
- PS4 assists fuel atomization and nozzle cooling

Fuel Nozzle



CT4072.19971009

Electronic Engine Control (EEC)

Purpose:

- The electronic engine control is used to reduce flight deck workload and to give thrust rating limiting control, N2 limiting, EPR calculation and indication, ARCCS scheduling, and EEC and related systems fault detection.

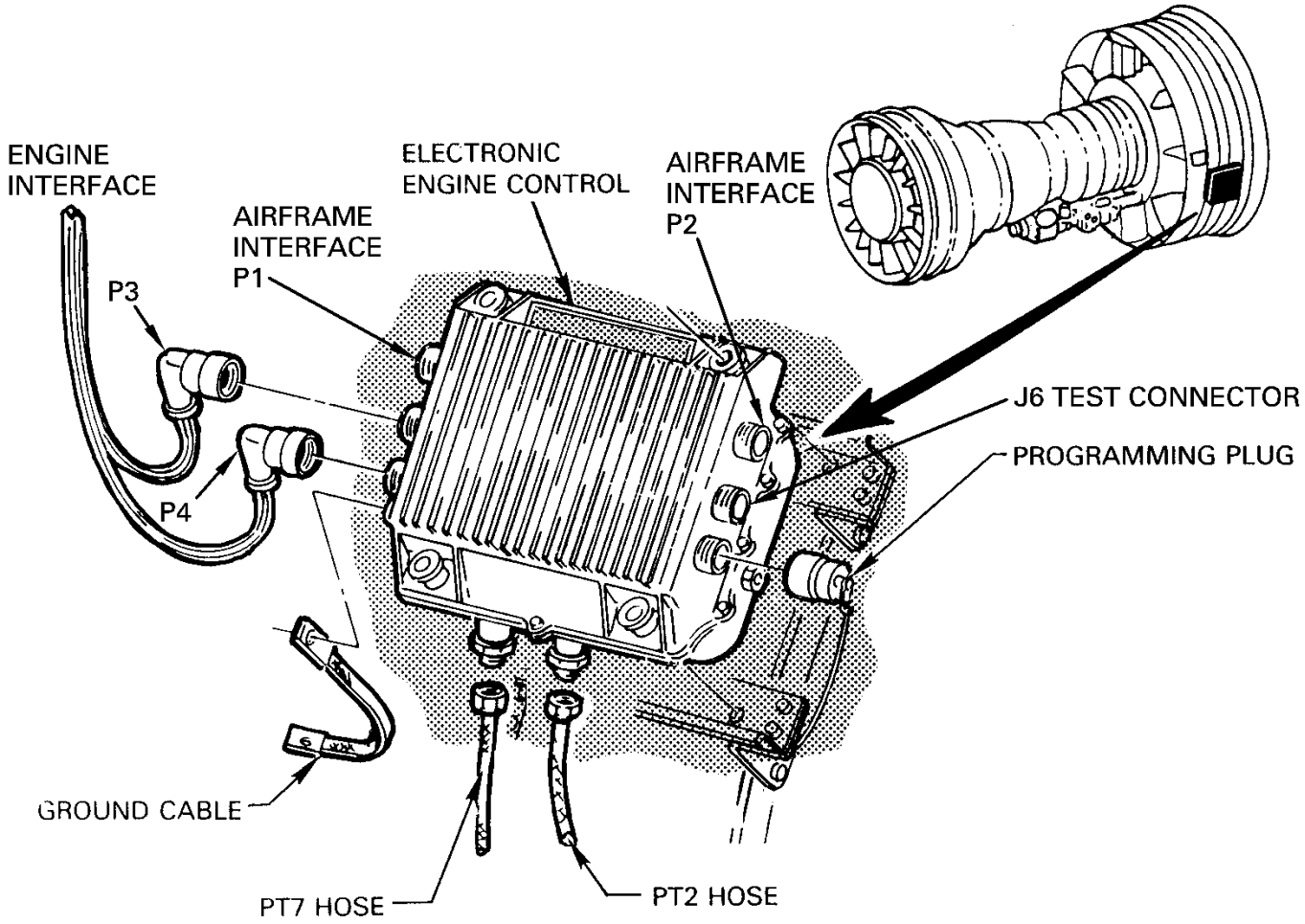
Location:

- The EEC is found on the fan case at the 5:00 position.

Description and Operation:

- Digital supervisory engine control
- Air cooled
- Vibration isolated
- Engine and aircraft interface connectors
  - Electrical
    - Two engine connectors
    - Two aircraft connectors
  - Pneumatic
    - PT7
    - PT2
  - Test connector
    - Electrical power for ground test memory interrogation
  - Programmable plug
    - Thrust rating identification
    - EPR / thrust normalization
    - Rating modification
    - Class determined by test data
    - Remains with engine

Electronic Engine Control



CT4073.19971009

CT4073

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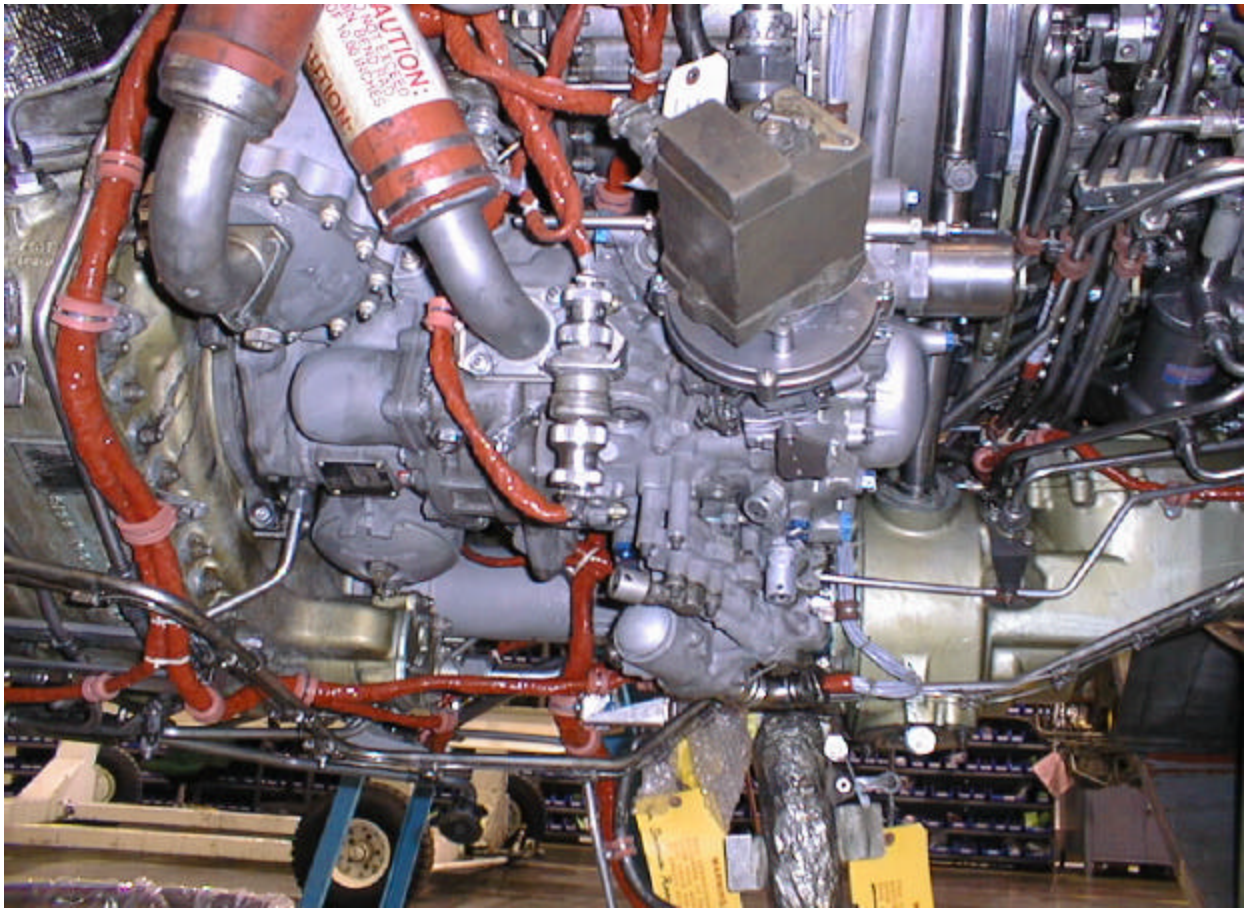
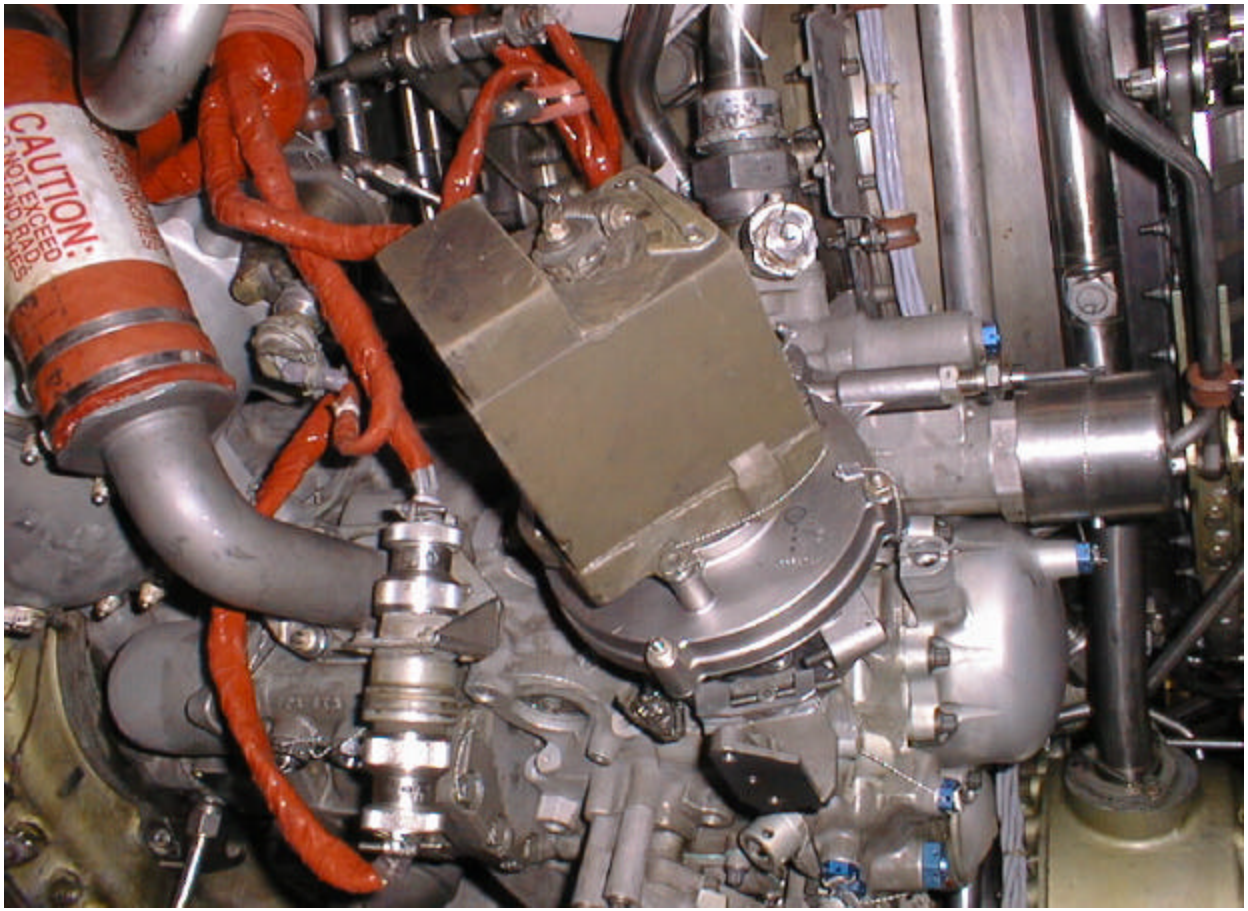
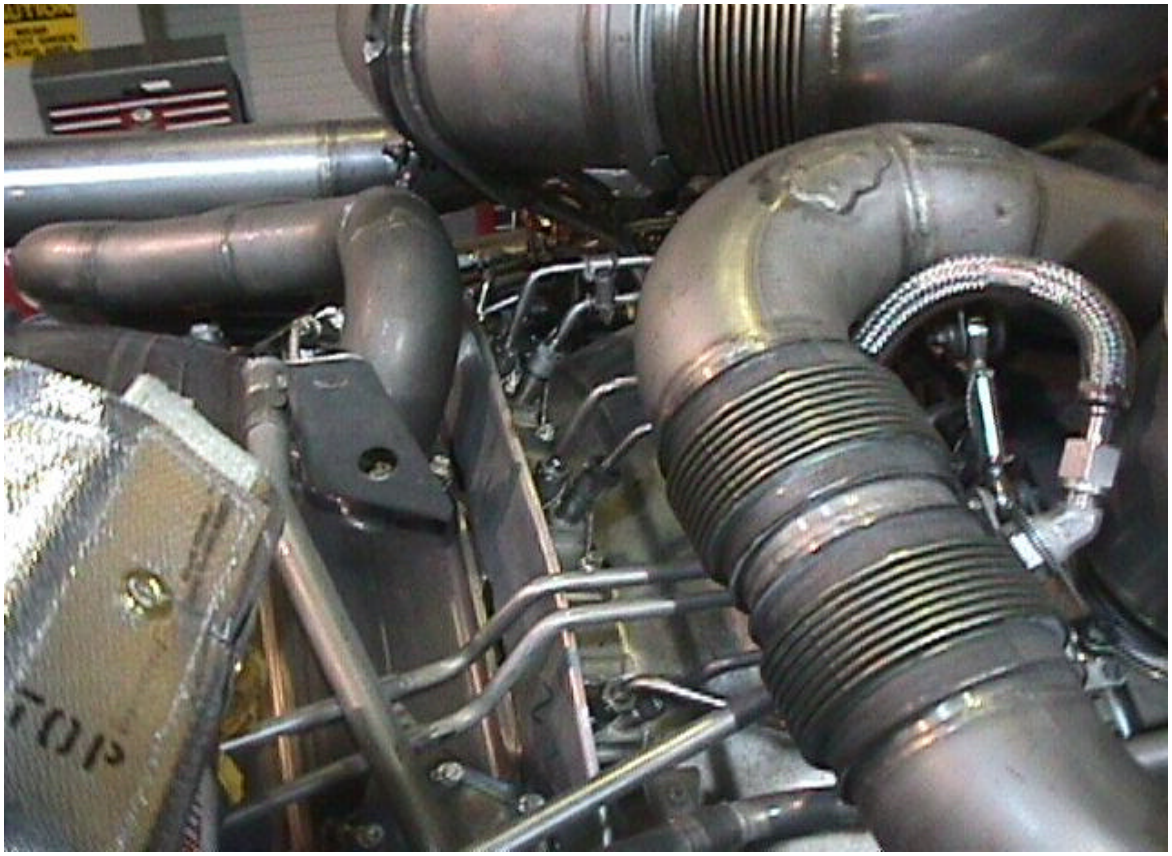
HP Fuel Shutoff Actuator



HP Fuel Shutoff Actuator (close-up)



Fuel Nozzles



Hydromechanical Fuel Control (HMC)

Purpose:

- The HMC supplies metered fuel used for starting, steady-state and transient operations, and does N2 and Ps4 limiting functions. It also supplies regulated hydraulic fuel pressure to the compressor airflow control system.

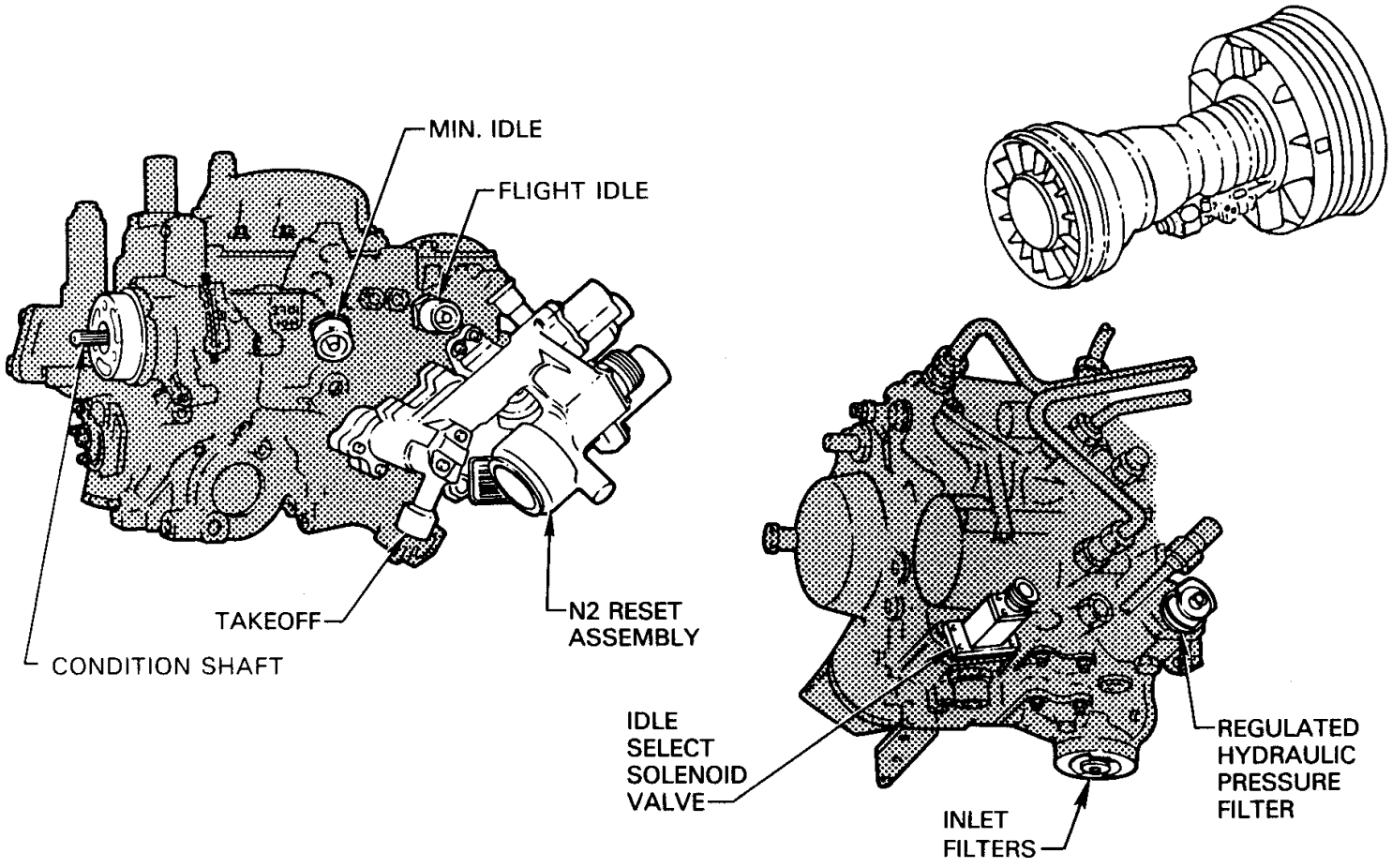
Location:

- The HMC is mounted on the front side of the fuel pump.

Description and Operation:

- Designated JFC68-10 (HSD)
- Has metering and computing sections (details on fuel metering are covered later in this section)
- Adjustments
  - Minimum idle trim
  - Flight idle trim
  - Takeoff trim
- Important features
  - Coarse (20 mesh screen) and fine (325 mesh screen) main filters
  - Fine (325 mesh screen) hydraulic stage fuel filter
  - Idle select solenoid
    - Line replaceable
    - Energized (minimum idle); on ground (reverser stowed)
    - De-energized (flight idle)

Fuel Control



CT4365

Fuel System Indication - Flow

Purpose:

- The fuel flow operating parameter indicates the current engine fuel flow and amount of fuel used.

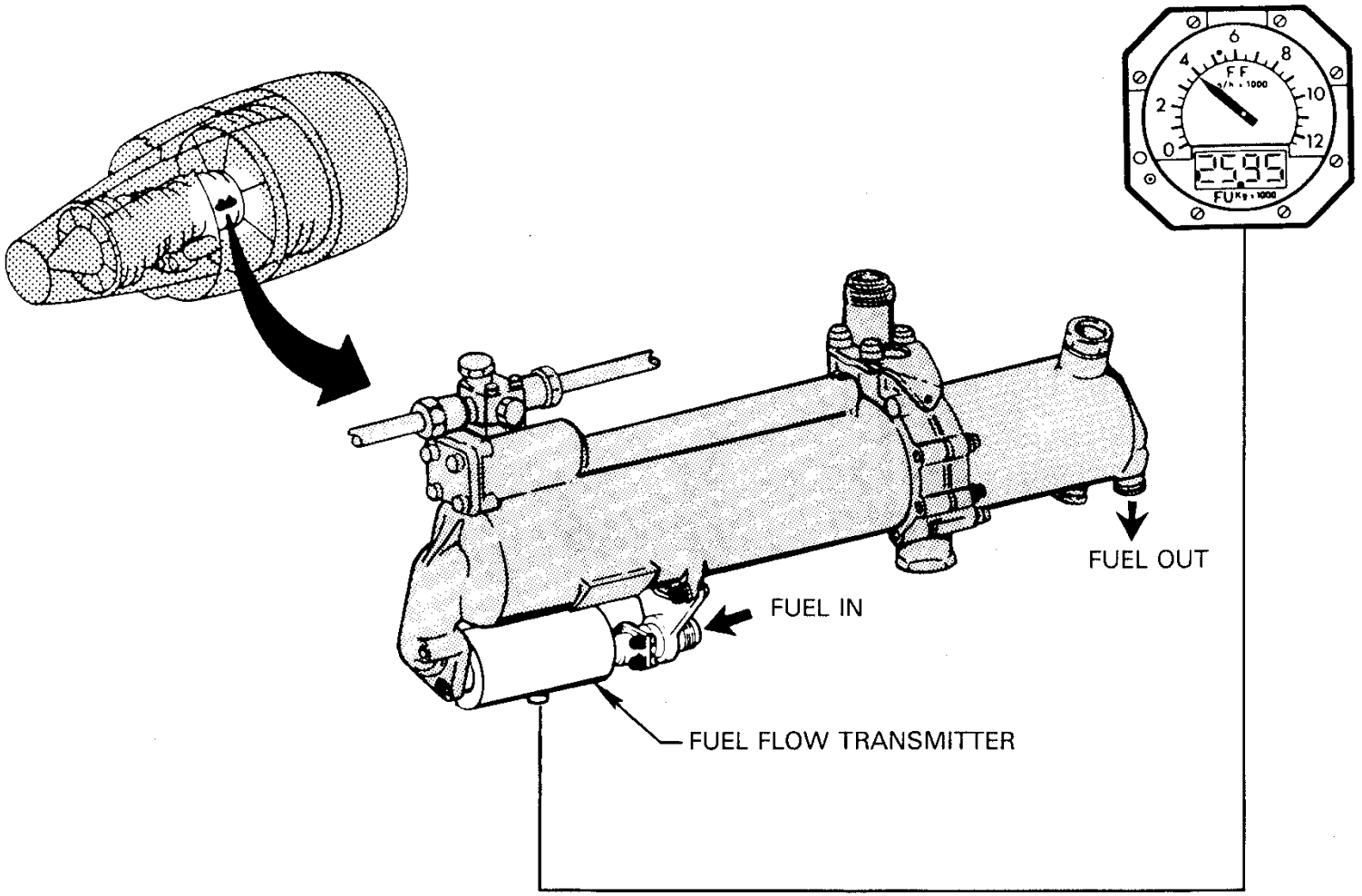
Components:

- Fuel flow transmitter
  - Found below the fuel / oil cooler at the 2:30 position
- Fuel flow analog indicator
  - Found on the cockpit center instrument panel

Description and Operation:

- Transmitter's fluid-driven rotor measures mass flow of fuel entering the fuel / oil cooler
- Signal generated from the transmitter is received by the fuel flow analog indicator
- Indicator shows the current rate of fuel flow in Kg/hr (range 0-12,500) or in pph (range 0-27,000) and a digital display of the total fuel used

Fuel System Indication - Flow



CT4048.19971009

CT4048

Fuel System Indication - Pressure

Purpose:

- The fuel pressure operating parameter indicates (on the right ECAM) fuel pump interstage pressure.

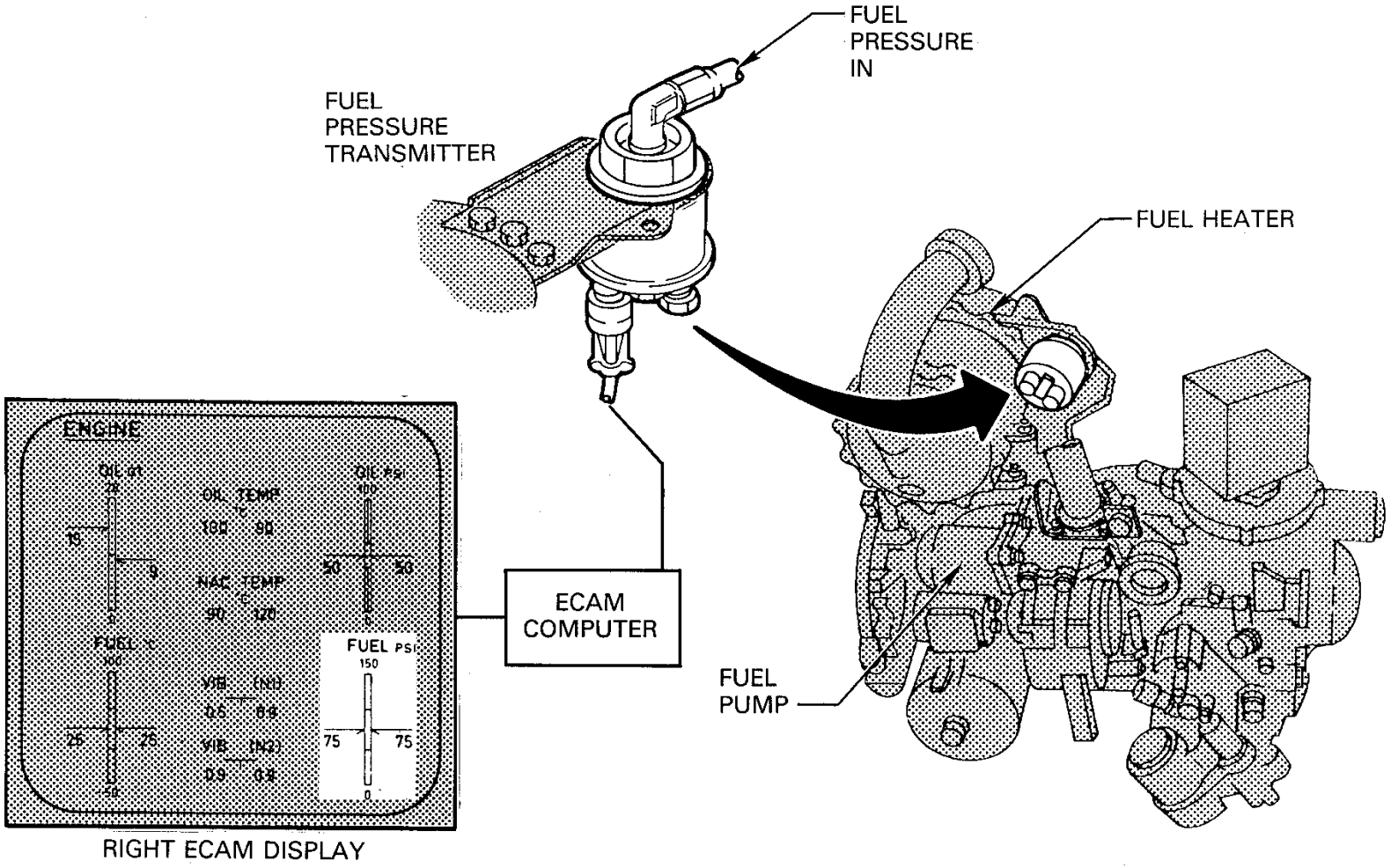
Components:

- Fuel pressure transmitter
  - Attached to bracket mounted on the fuel heater
- Fuel pressure indicator
  - Displayed in the lower right quadrant of engine pages on the right ECAM CRT

Description and Operation:

- Fuel pump interstage pressure is sensed at pressure port FP8 on the fuel pump
- Transmitter's electrical output signal is processed by the ECAM computer for display in psi on the lower right quadrant of engine pages on the right ECAM CRT

Fuel System Indication - Pressure



RIGHT ECAM DISPLAY

CT4028.19971009

CT4028

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DRAIN SYSTEM

Overall System Data

GENERAL

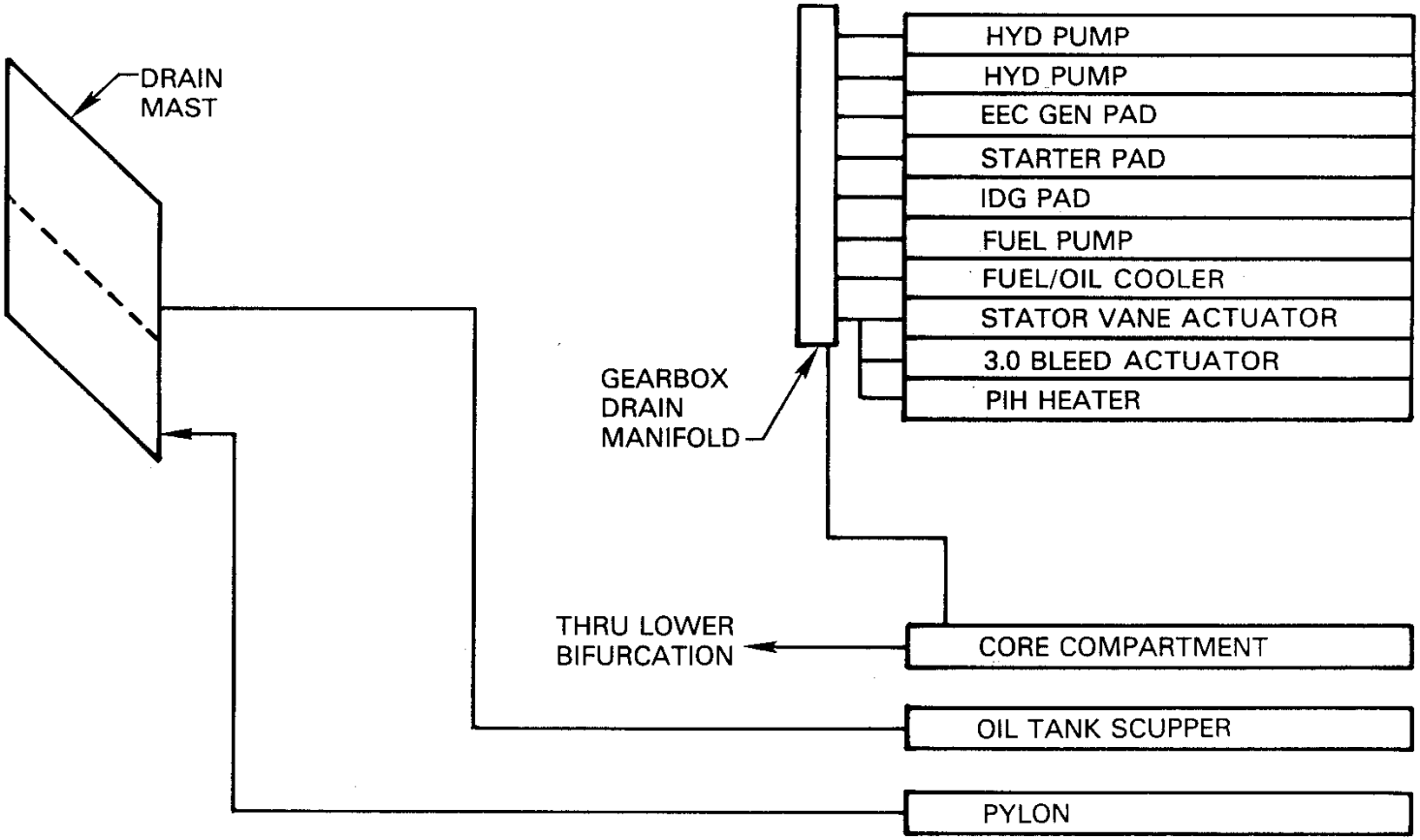
Purpose:

- The drain system is used to collect and discharge drain fluids including fuel, engine oil, IDG oil, and hydraulic fluid.

Components:

- Gearbox drain manifold and drain lines
- Drain mast
- Oil tank scupper
- Pylon drain

Drain System Schematic



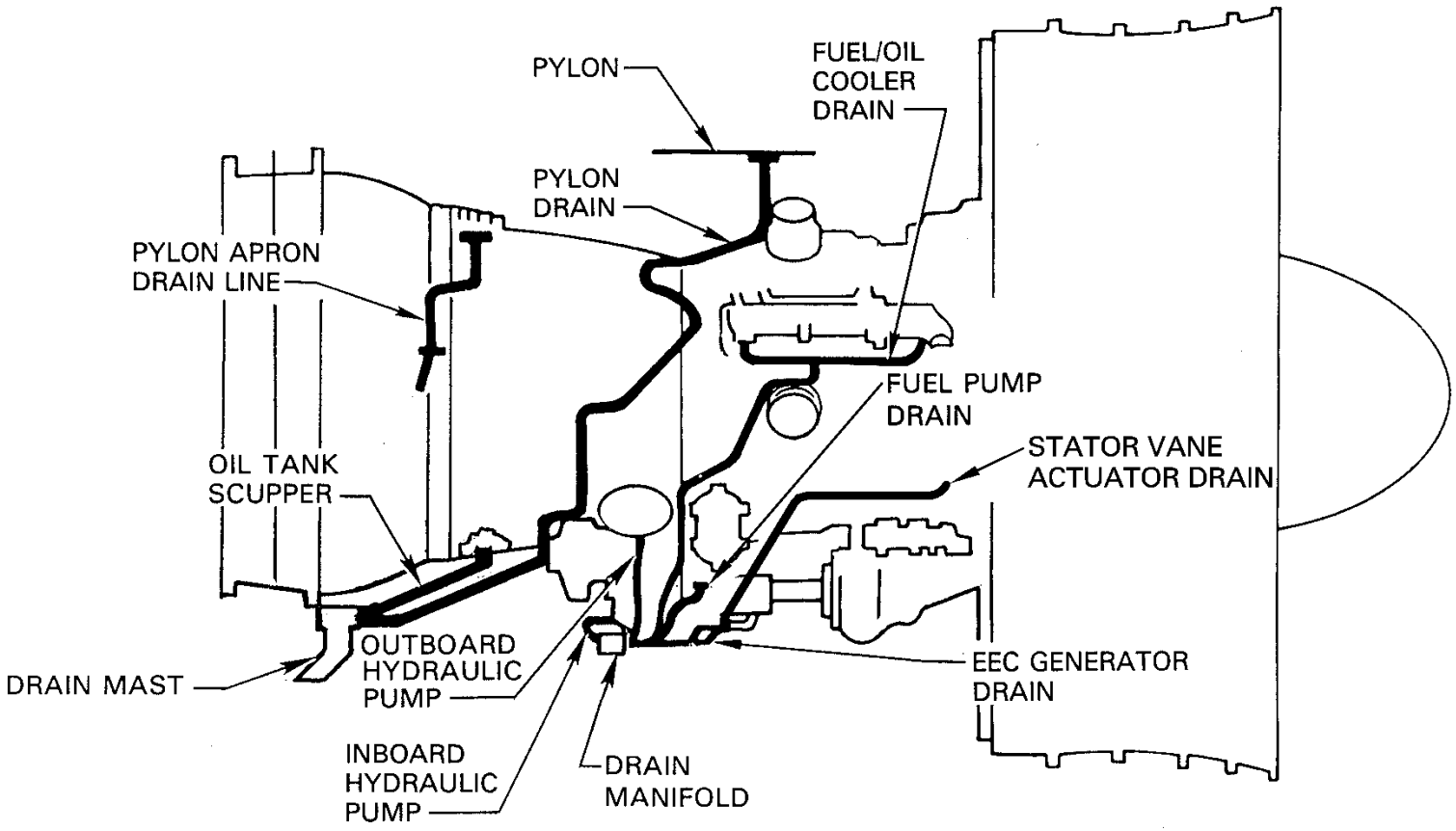
CT4314.19971009

CT4314

Engine Drain Lines - Right Side

- Accessory drains
  - Fuel / oil cooler drain
  - Fuel pump drain
  - Stator vane actuator drain
  - EEC generator drain
  - Hydraulic pump drains
- Drain manifold
- Drain mast
- Pylon drains

Engine Drain Lines - Right Side



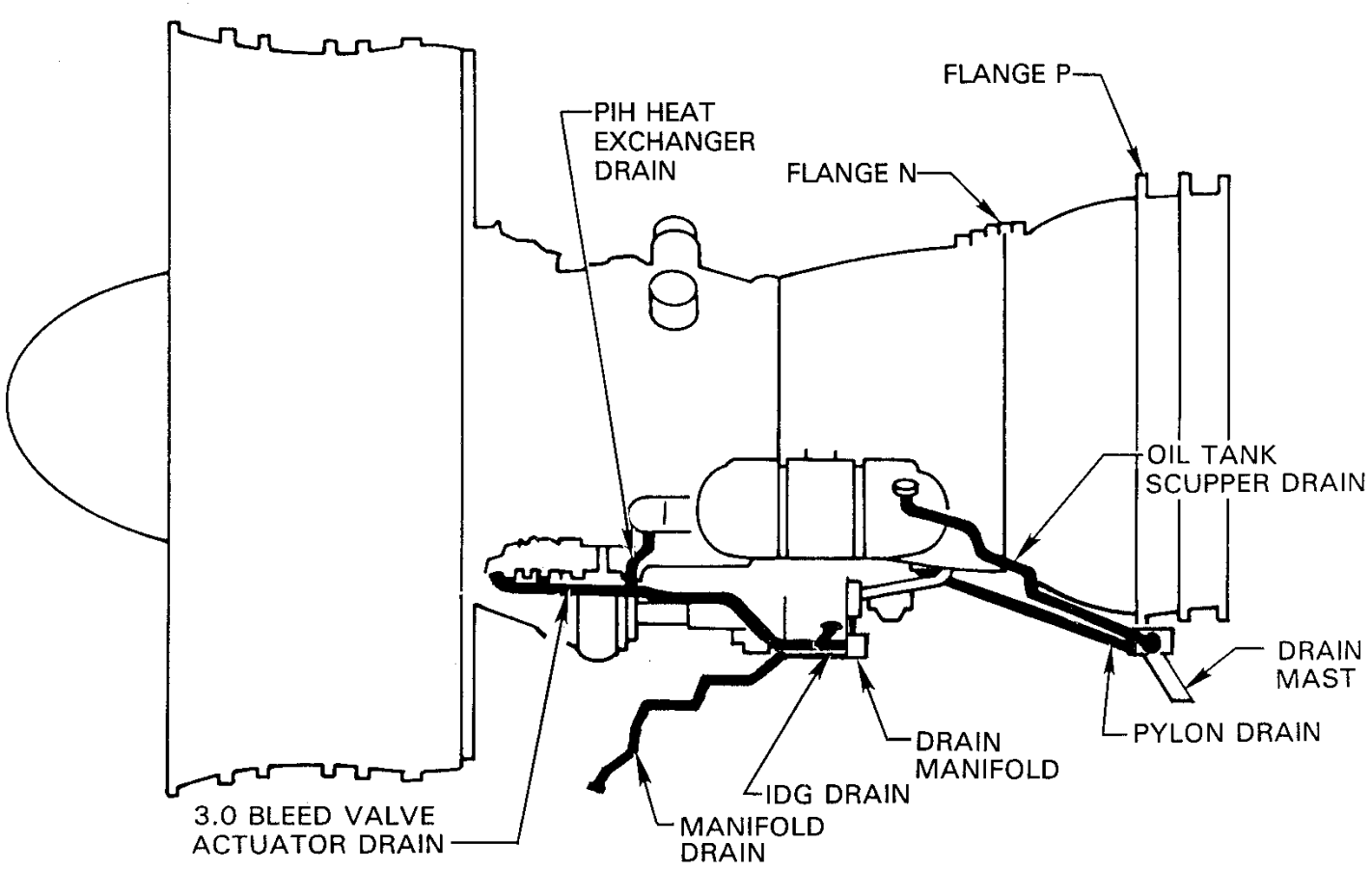
CT4157.19971010

CT4157

Engine Drain Lines - Left Side

- Accessory / component drains
  - 3.0 actuator drain
  - PIH heat exchanger drain
  - IDG drain
  - Oil scupper drain
- Pylon drain
- Drain mast
- Manifold drain

Engine Drain Lines - Left Side



CT4158.19971010

CT4158

Drain Manifold and Drain Lines

Purpose:

- The drain manifold and drain lines are used to collect and route drain fluids.

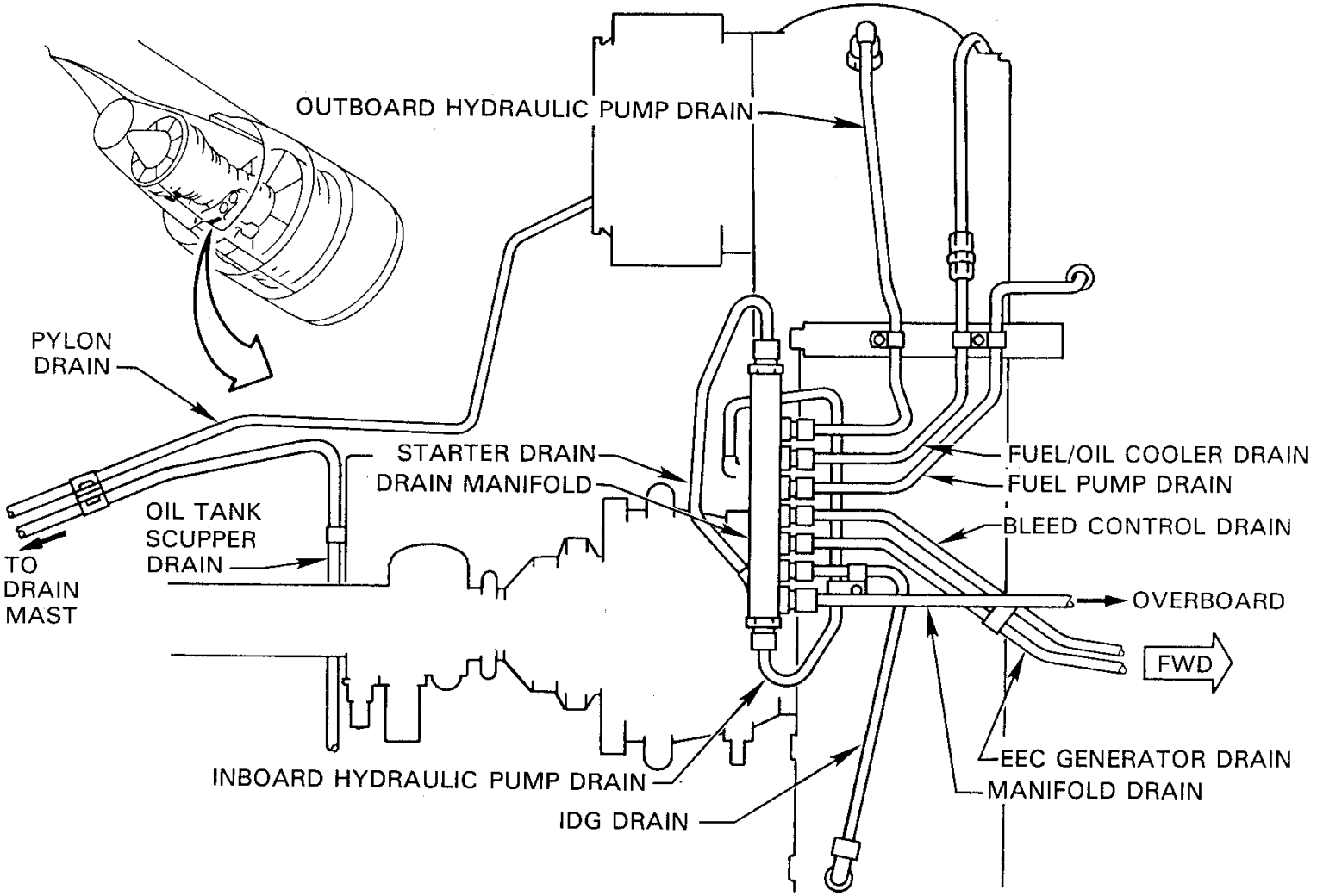
Location:

- The drain manifold and drain lines are mounted on the rear of the main gearbox at the 6:00 position.

Description and Operation:

- The drain manifold collects and routes fluids overboard.

Drain Manifold and Drain Lines



CT4313

Drain Mast

Purpose:

- The drain mast is used to drain oil tank scupper and pylon drain overboard.

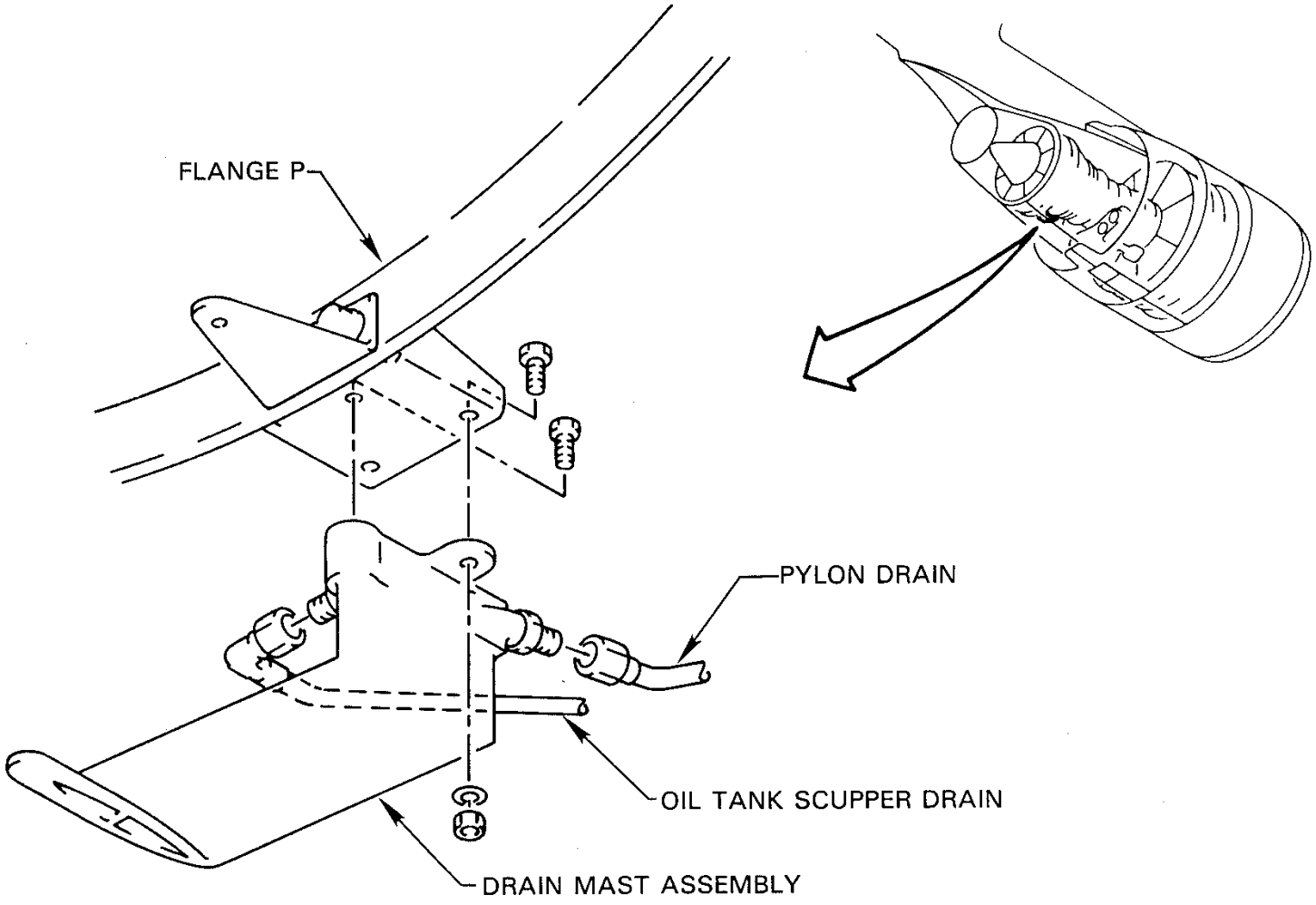
Location:

- The drain mast is found on the lower centerline of the engine -- forward of the turbine exhaust case.

Description and Operation:

- The oil tank scupper drain is segregated from the pylon drain.

Drain Mast



CT4312.19971010

CT4312

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HYDROMECHANICAL AND ELECTRONIC ENGINE CONTROL SYSTEMS

Overall System Data

GENERAL

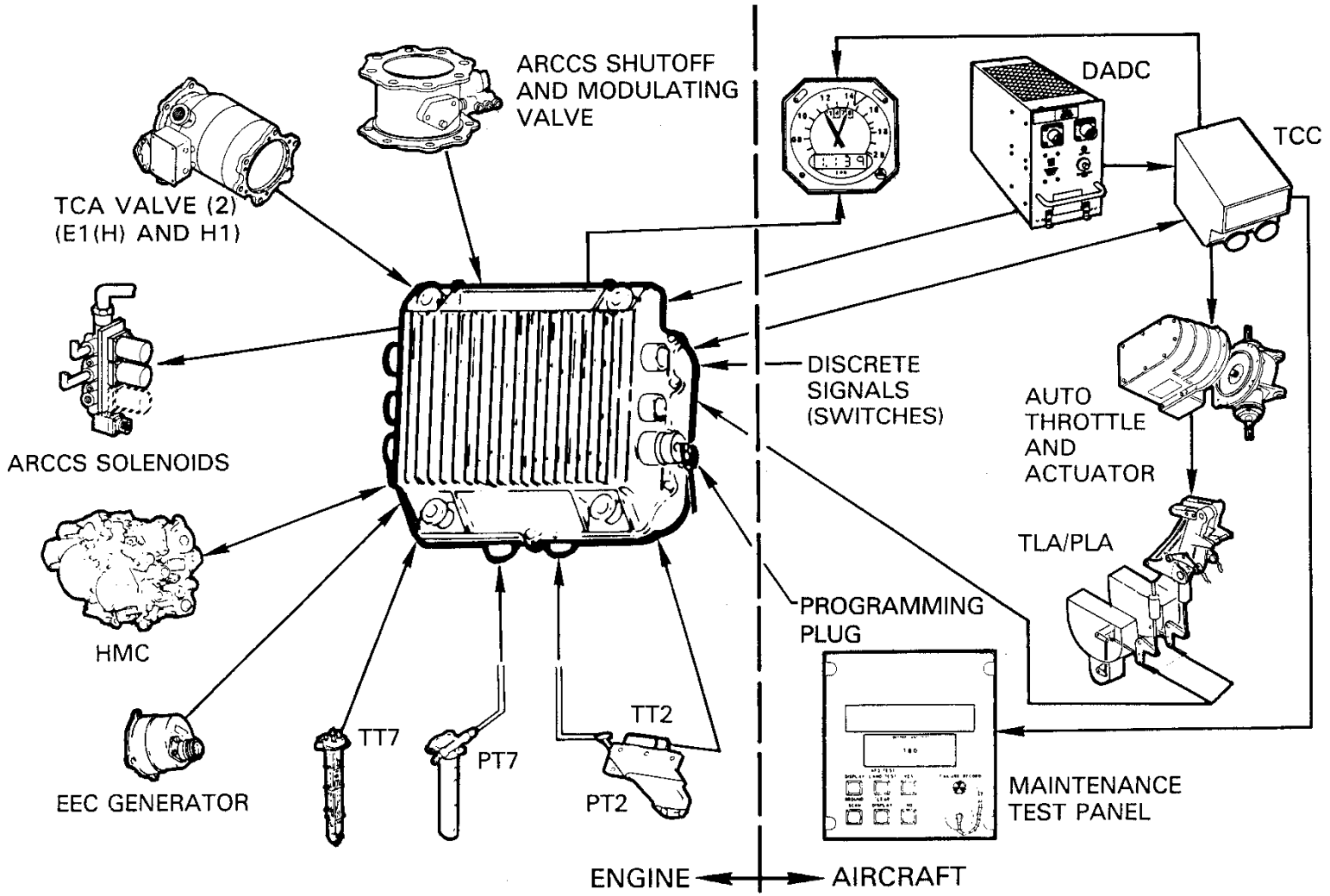
Purpose:

- The hydromechanical and electronic engine control systems are used to control engine operating parameters and performance for:
  - Engine start.
  - Acceleration.
  - Deceleration.
  - Steady state.
  - Preventing N2 exceedance.
  - Preventing EPR overshoot / overboost
  - Automatic Rotor Clearance Control System (ARCCS) scheduling
- Reduce flight deck workload
- Reduce throttle stagger
- Calculate and transmit EPR for display
- Track, store, and transmit EEC and associated system faults
- Limit thrust rating at fixed discrete TLA / PLA positions

Components:

- Engine-mounted:
  - EEC
  - Hydromechanical fuel control (HMC)
  - ARCCS solenoid valve (5-way)
  - ARCCS modulating and shutoff valve
  - TCA valves (E1(600) and H1 only)
  - EEC generator
  - PT7 / TT7 probes
  - PT2 / TT2 probe
- Aircraft-mounted
  - EPR indicator
  - Digital Air Data Computer (DADC)
  - Thrust Control Computer (TCC)
  - Thrust levers and resolvers
  - Maintenance Test Panel (MTP)
  - Auto throttle actuator

EEC/Component Interface



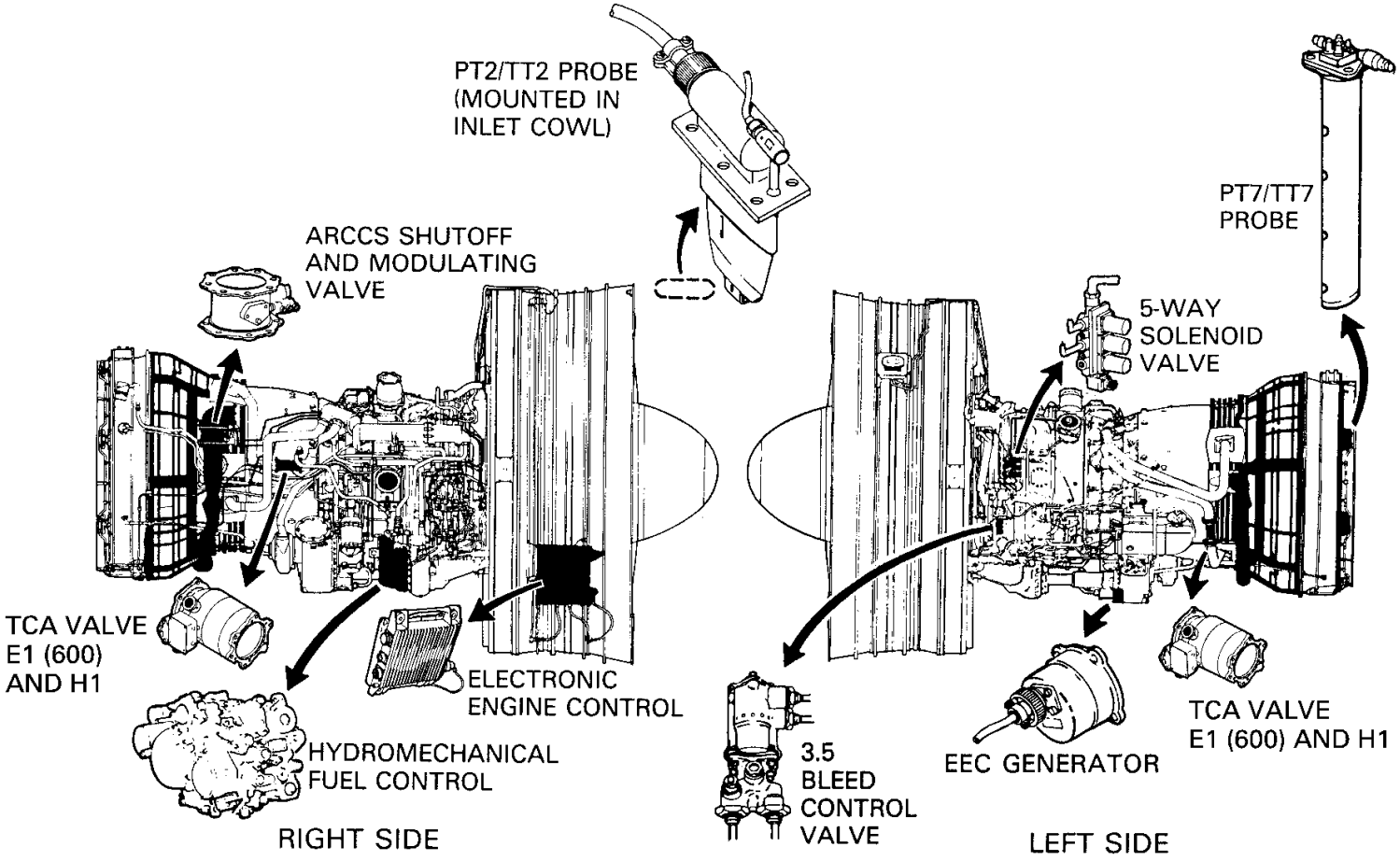
CT4074.19971009

CT4074

Engine-Mounted Component Locations

- Electronic Engine Control (EEC)
  - Mounted on the fan case at the 4:30 position
- Hydromechanical fuel control
  - Mounted on the front face of the fuel pump
- ARCCS solenoid valve (5-way)
  - Mounted on the HPC at the 9:30 position
- ARCCS shutoff modulating valve
  - Found on the HPT case at the 2:30 position
- TCA valves (2) (E1(600) and H1 only)
  - Found in the upper right and lower left 13th stage ducts
- EEC generator
  - Mounted on the front center of the main gearbox
- PT7 / TT7 probes (6)
  - Mounted in the turbine exhaust case
- PT2 / TT2 probe
  - Mounted in the inlet cowl at the 1:00 position
- 3.5 bleed control valve
  - Mounted in the compressor intermediate case at the 8:00 position

Engine-Mounted Control System Components



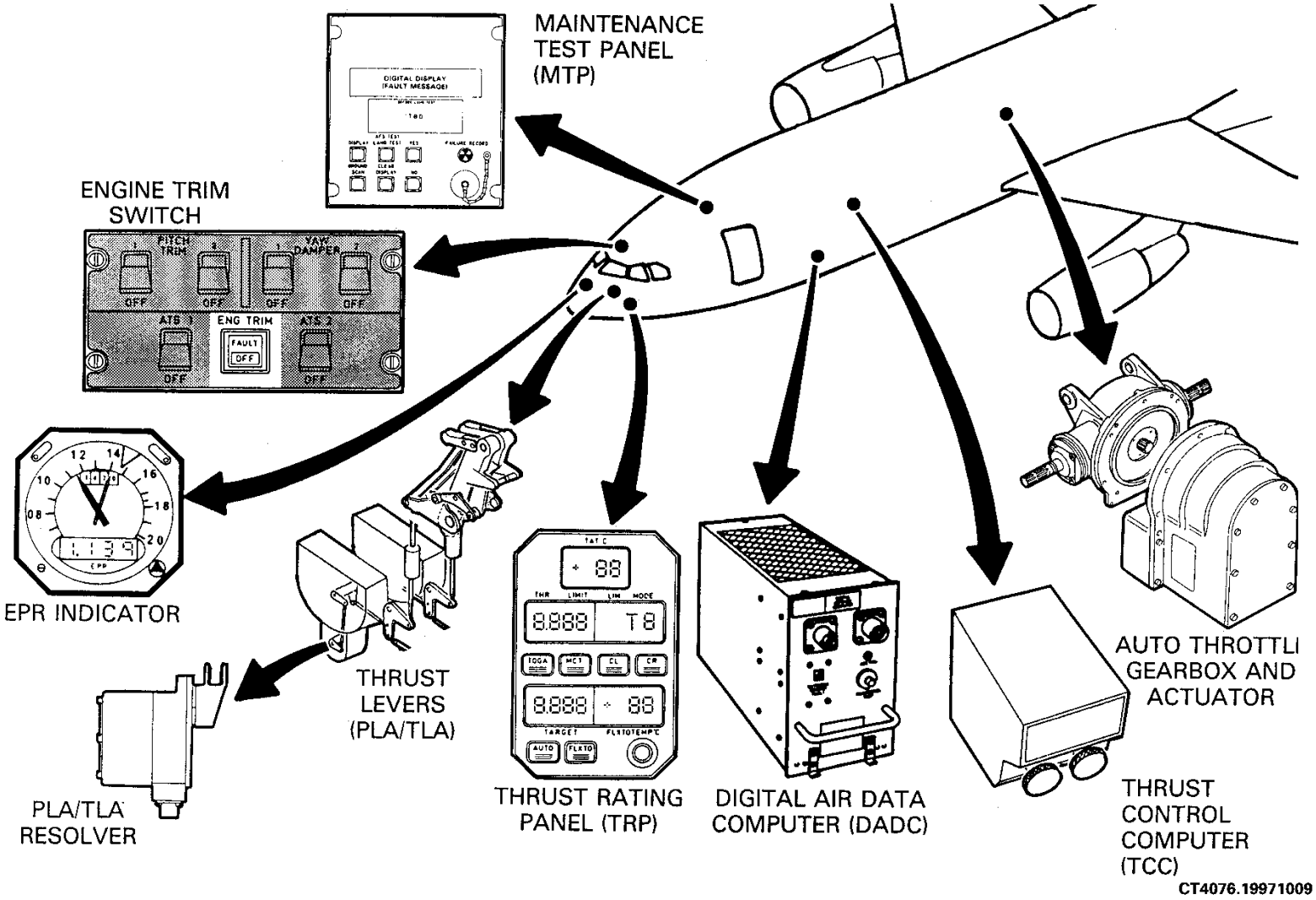
CT4075.19980612

CT4075

Aircraft-mounted Component Locations

- EPR indicator
  - Found on the center main instrument panel
- Digital Air Data Computer
  - Found in the left electronics rack
- Thrust Control Computer
  - Found in the left electronics rack
- Thrust Rating Panel
  - Found on the center panel in the flight deck
- Thrust levers and resolver
  - Found on the center console in the cockpit
- Maintenance Test Panel
  - Found on the rear panel in the cockpit
- Autothrottle gearbox and actuator
  - Found in the lower fuselage (center wing section)
- Engine trim switch
  - Found on the autothrottle system control panel

Aircraft-Mounted Control System Components



Electronic Engine Control (EEC) - Components

Purpose:

- The EEC is used to reduce flight deck workload and supply thrust rating limiting control, N2 limiting, EPR calculation and indication, ARCCS scheduling, and EEC and related system fault detection.

Location:

- The EEC is found on the fan case at the 5:00 position.

Description and Operation:

- Digital supervisory engine control
- Engine and aircraft interface connectors
  - Electrical
  - Pneumatic
  - Test connector
  - Programming plug

PT2/TT2 PROBE

Purpose:

- The PT2 / TT2 probe gives inlet total pressure and temperature to the EEC for thrust rating selection and limiting, EPR calculation, and synthesis.

Location:

- The PT2 / TT2 probe is found in the inlet cowl at the 1:00 position.

Description and Operation:

- Variable resistance temperature setting
- Electrically anti-iced
  - Controlled from probe heat panel
  - 115 VAC, 400Hz, 425 watts (max)

PT7/TT7 PROBES (6)

Purpose:

- The PT7 / TT7 probes supply total temperatures and pressure sense of the the engine exhaust for EPR and EGT indication.

Location:

- The PT7 / TT7 probes are found in the turbine exhaust case.

Description and Operation:

- Total pressure for EPR
- Average temperature for EGT indication
  - Chromel / alumel junction

EEC GENERATOR

Purpose:

- The EEC generator is a dedicated electrical power source for the EEC and supplies N2 speed for the EEC N2 limiting function.

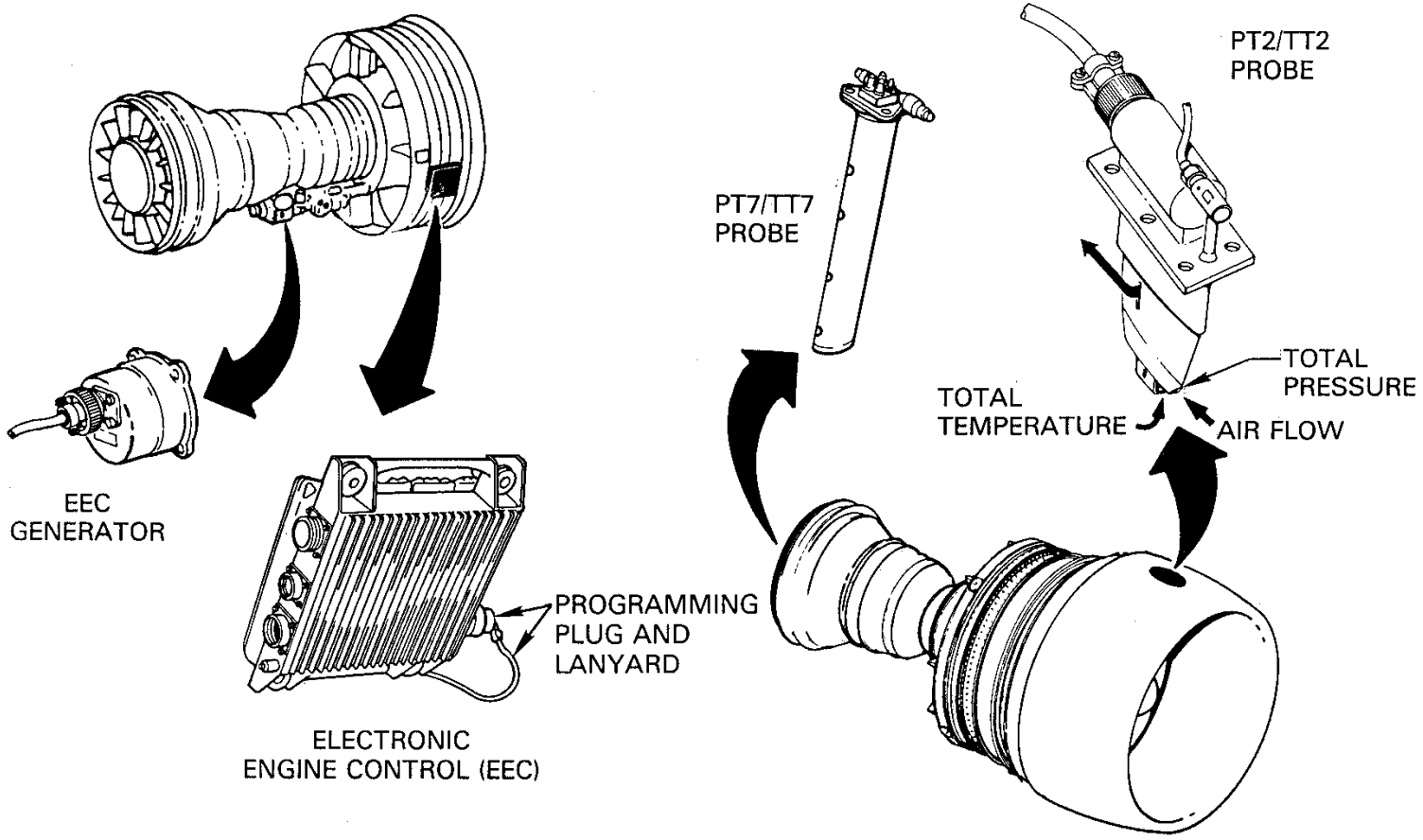
Location:

- The EEC generator is found on the front of the main gearbox.

Description and Operation:

- Three phase permanent magnet generator
- Separate rotor and stator

EEC, EEC Generator and Temperature/Pressure Probes



CT4077.19971009

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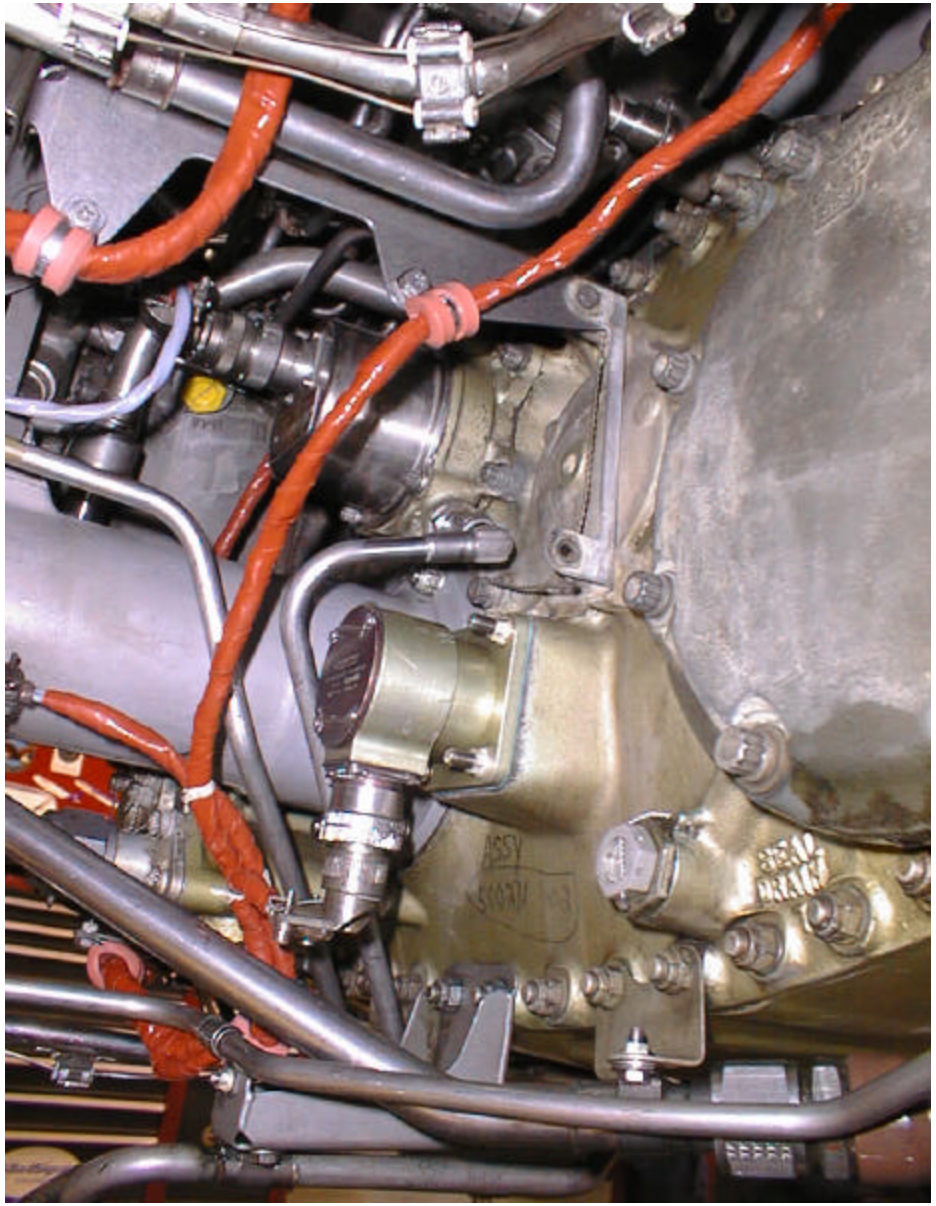
EEC Generator



Airflow Control Valves

5-WAY SOLENOID VALVE

Purpose:

- The 5-way solenoid valve is used to pneumatically control the ULH 3.5 bleed valve, ARCCS shutoff and modulating valve for all models and the TCA valves for the E1(600) and H1 models only.

Location:

- The 5-way solenoid valve is found on the HPC at the 9:30 position.

Description and Operation:

- Inputs
  - Aircraft-supplied 28VDC
  - PS4 from 3.5 bleed control valve
- Output
  - PS4 to ARCCS shutoff and modulating valve and the ULH 3.5 bleed valve

ARCCS SHUTOFF AND MODULATING VALVE

Purpose:

- The ARCCS shutoff and modulating valve controls fan airflow to the turbine case cooling manifolds.

Location:

- The ARCCS shutoff and modulating valve is found on the HPT at the 2:30 position.

Description and Operation:

- Four position butterfly valve
  - Off
  - Minimum flow
  - Intermediate flow
  - Maximum flow
- Pneumatically controlled
- PS4 ports

TURBINE COOLING AIR VALVES (E1(600), H1)

Purpose:

- The turbine cooling air valves are used to control 13th stage air for HPT internal cooling.

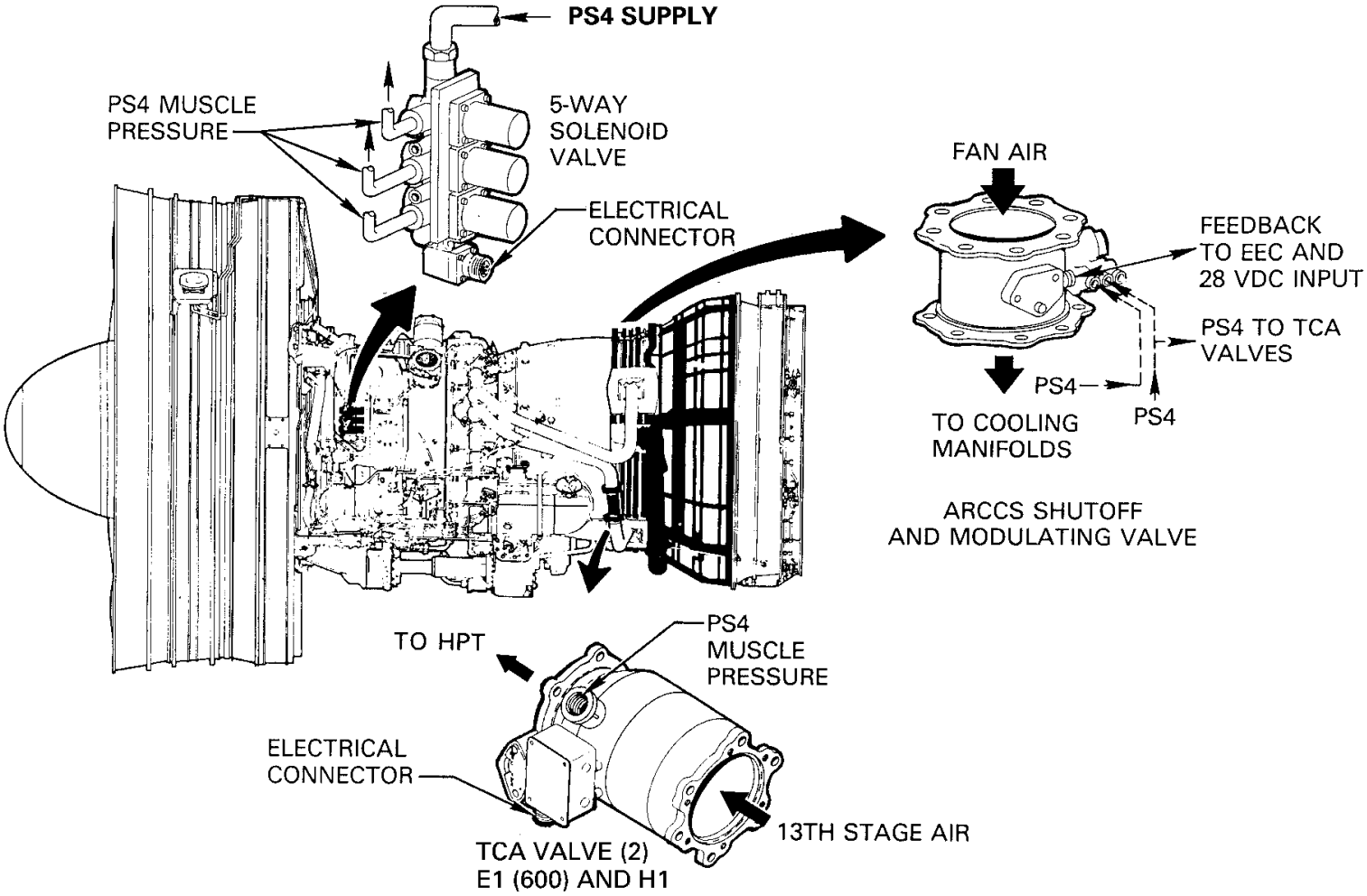
Location:

- The turbine cooling air valves are found in the upper right and lower left 13th stage cooling ducts.

Description and Operation:

- Two position valve
  - Open
  - Close
- Pneumatically controlled PS4

Airflow Control Valves



CT4078.19980612

CT4078

PLA/TLA Input Devices

THRUST CONTROL LEVERS

Purpose:

Provides manual thrust control

Location:

Center console in cockpit

Description and Operation:

The throttle control system is comprised of throttle control levers, rods, cables, and a hydromechanical fuel control mounted gearbox. Movement of the throttle control lever results in rotation of the power lever arm on the hydromechanical fuel control resulting in changes in metered fuel flow.

TLA RESOLVER

Purpose:
Provides TLA information to the EEC and TCC

Location:

Center console below thrust levers

Description and Operation:

Throttle position system is comprised of two rotary transformer angle resolvers. The EEC TLA resolver is driven directly through the throttle mechanism, while the TCC TLA resolver is driven by a 1:1 gear train from the EEC resolver.

AUT0THROTTLE ACTUATOR

Purpose:

Drives the engine throttle system as a function of TCC generated signals

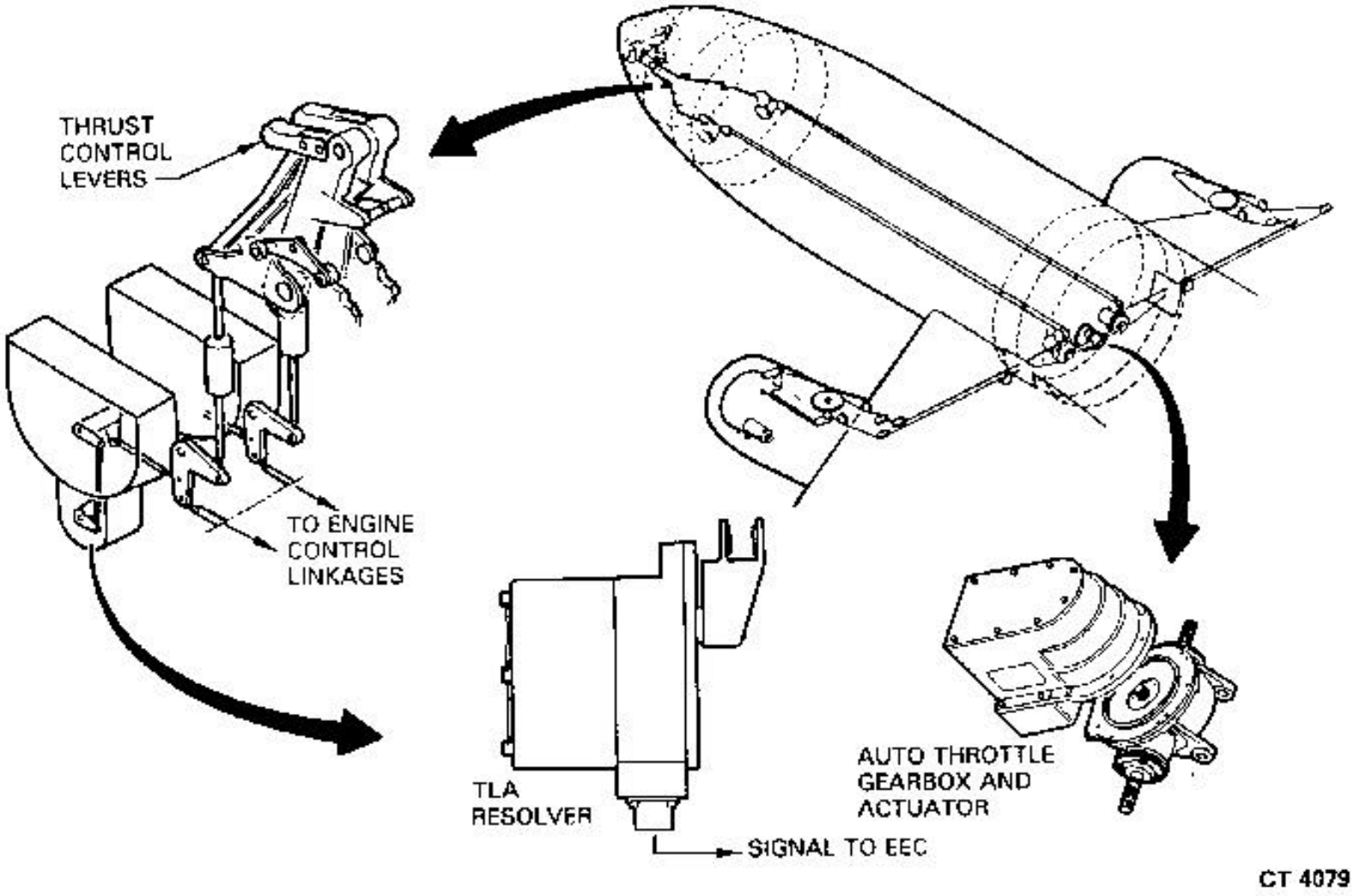
Location:

Lower fuselage, center wing section

Description and Operation:

The autothrottle actuator is composed of a DC motor, tachometer generator, and a three stage speed reducer. The TCC generated signals cause rotation of the motor and displacement of the engine throttle system. The tachometer generator controls response rate and provides feedback logic.

PLA/TLA Input Devices



Hydromechanical and Electronic Engine Control Systems Components

DIGITAL AIR DATA COMPUTER

Purpose:

Processes pressure and temperature to provide environmental data to the navigation, flight control, and thrust control systems.

Location:

Located in left hand electronics rack

Description and Operation:

Two identical air data computers receive pressure and temperature information from pitot static probes and supply the information to the following systems: - Autopilot - Autothrottle - Flight management - Thrust management - Air traffic control - Ground proximity warning

THRUST CONTROL COMPUTER

Purpose:

Computing of EPR limit based on operational mod air data and systems status
Reduces flight crew workload related to engine management

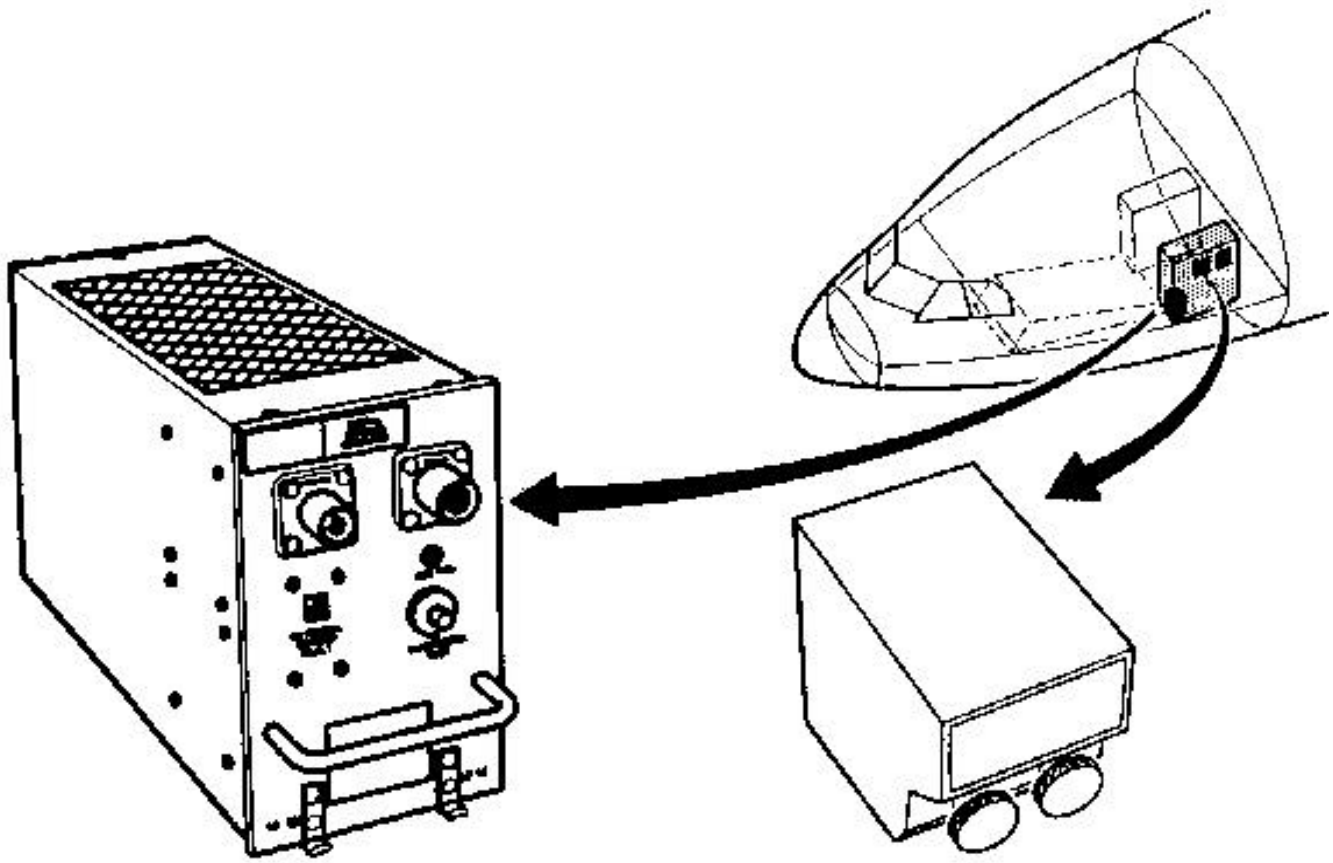
Location:

Located in left hand electronics rack

Description and Operation:

The thrust control computer is an element of the Auto- Flight System which is comprised of:
- Flight control computer
- Flight augmentation computer
- Thrust control computer
- System monitor

Control System Components



Indicators and Control Panels

THRUST RATING PANEL

Purpose:

- The thrust rating panel gives communication between the flight crew and the thrust control computer.

Location:

- The thrust rating panel is found on the center panel on the flight deck.

Description and Operation:

- Total air temperature
- Thrust limit - EPR
- Limit mode
- Mode select switches
- Target EPR - FMC mode only
- Auto / flex takeoff select switches
- Flex - takeoff temperature select

EPR INDICATOR

Purpose:

- The EPR indicator shows engine pressure ratio for setting and managing thrust.

Location:

- The EPR indicator is found on the center panel on the flight deck.
- EPR Limit Index:
  - Indicates EPR limit
  - Driven by TCC
  - Can manually be set
  - Digital repeat - manual mode

Description and Operation:

- EPR Command
  - Indicates commanded EPR
  - Driven by EEC
  - Striped pointer
- EPR Actual
  - Indicates actual EPR
  - Driven by the EEC
  - White pointer
  - Digital repeat

ENGINE TRIM SWITCH

Purpose:

- The engine trim switch permits EEC ON / INHIBIT control and fault indication.

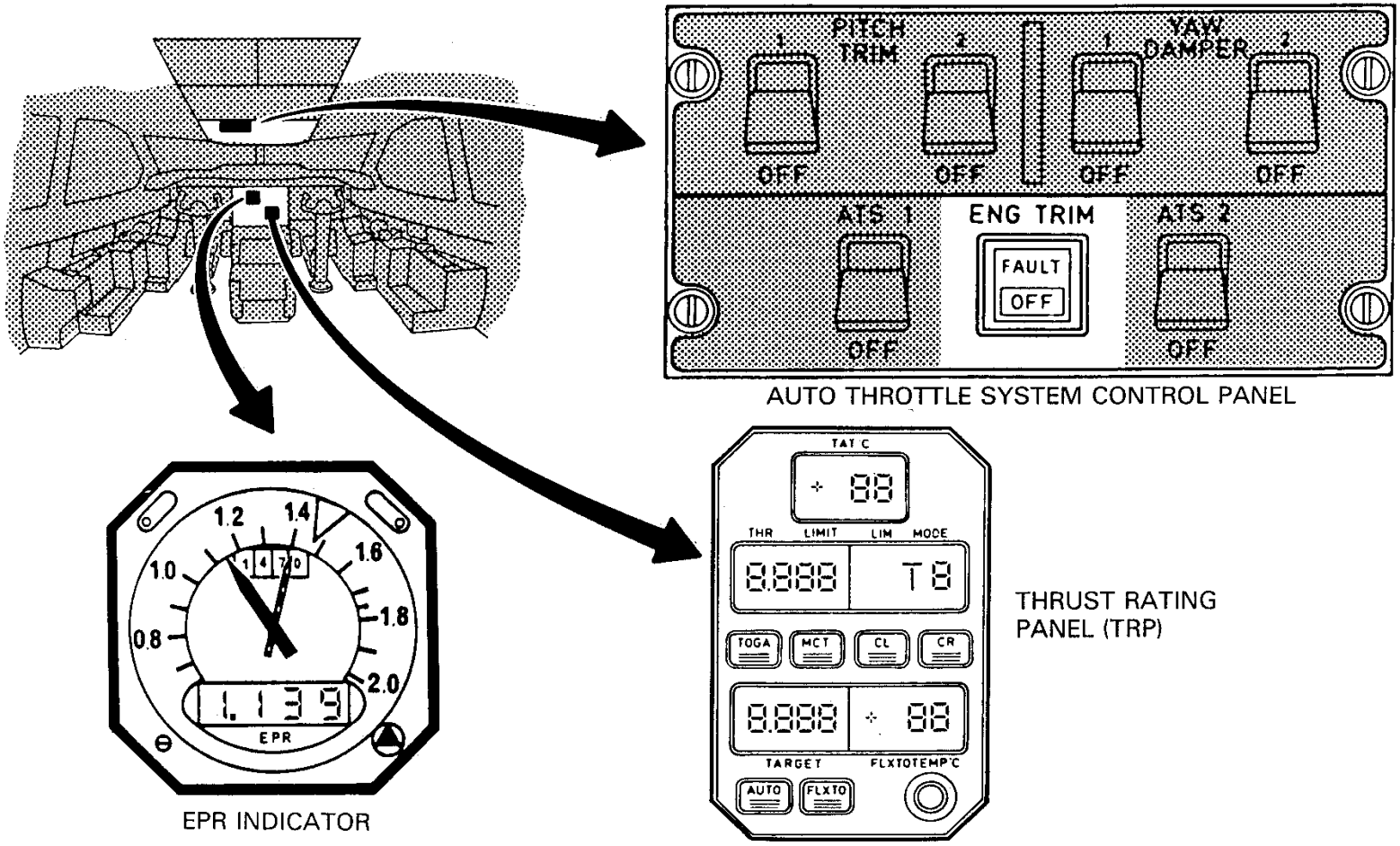
Location:

- The engine trim switch is found on the autothrottle system control panel.

Description and Operation:

- Push switch - controls EEC1 and EEC2
  - ON - not illuminated
  - OFF - illuminated white
  - Fault - illuminated amber

Indicators and Control Panels



CT4081

Maintenance Test Panel

Purpose:

- The maintenance test panel permits interrogating auto-flight system computers for status and faults.

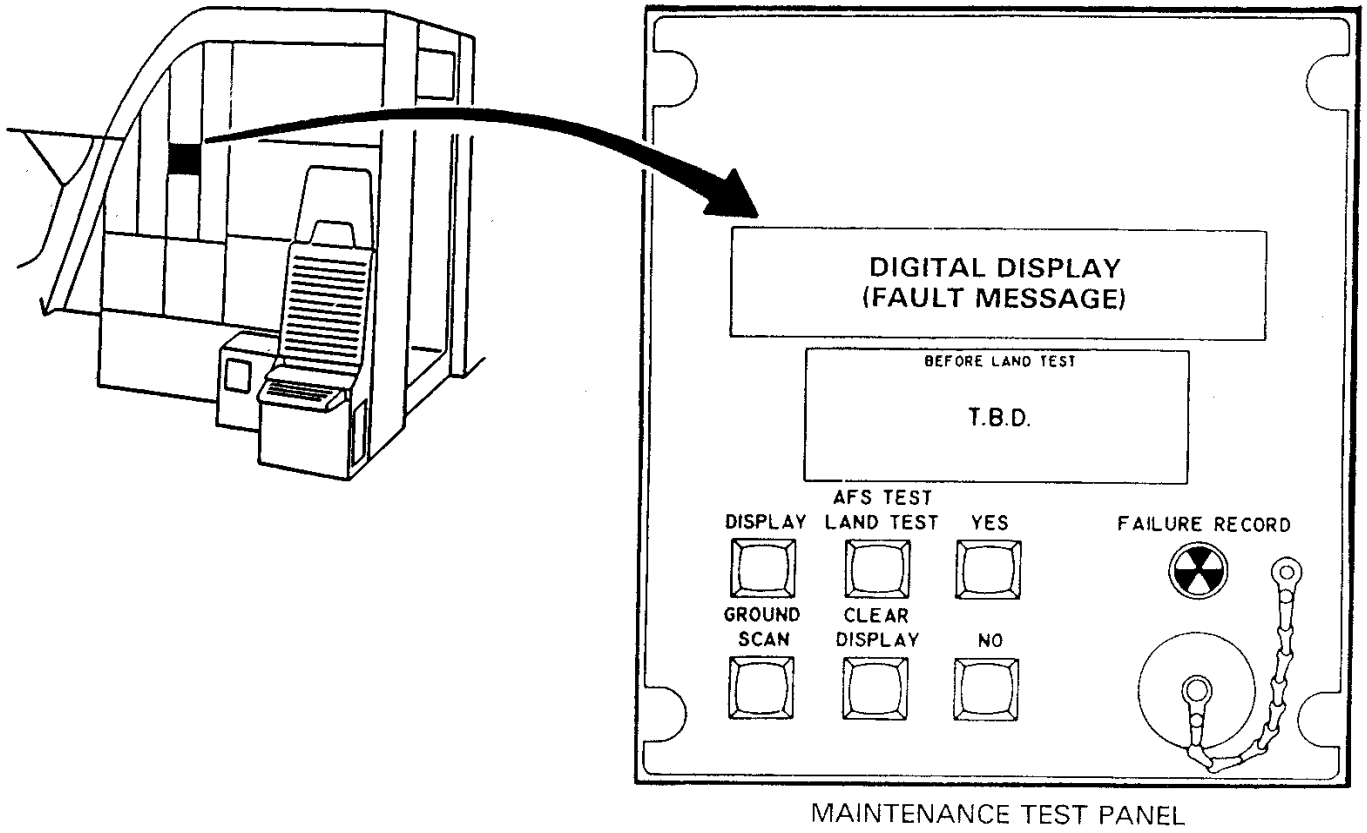
Location:

- The maintenance test panel is found on the flight deck rear panel.

Description and Operation:

- Display window
  - Two rows
  - 16 alphanumeric characters
  - Status and fault messages
  - Six EEC faults
- Keyboard
  - Six push switches
  - Display switch calls up messages
  - Automatically cycles through all messages in sequence
- Failure record
  - Indicates that a fault was recorded
- Electrical connector
  - Interface between MTP and maintenance information printer
  - Interface with autoflight system computer's monitoring and command channels

Auto Flight System Maintenance Test Panel



MAINTENANCE TEST PANEL

CT4082.19971009

CT4082

Hydromechanical and Electronic Engine Control Systems Components

HYDROMECHANICAL FUEL CONTROL (HMC)

Purpose:

- The hydromechanical fuel control:
  - Supplies metered fuel for starting, steady state, and transient operations.
  - Performs N2 and PS4 limiting functions.
  - Supplies regulated hydraulic fuel pressure to the compressor airflow control system.

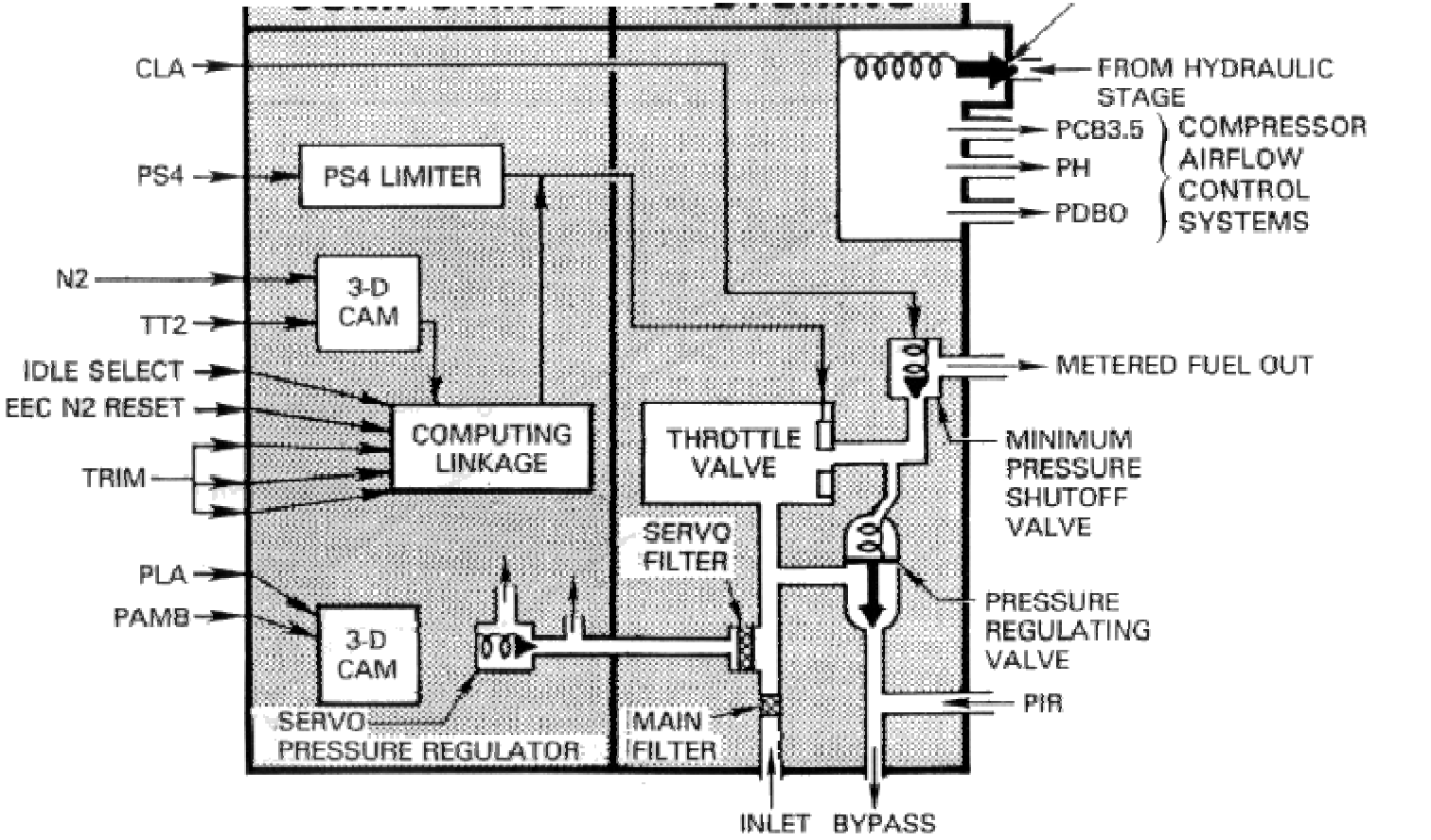
Location:

- The hydromechanical fuel control is mounted on the forward face of the fuel pump.

Description and Operation:

- Designated JFC68-10 (HSD)
- Has metering and computing sections
- Inputs
  - Pressurized fuel from fuel pump (both main and hydraulic pump stages)
  - TLA / PLA
  - CLA
  - N2
  - PS4
  - TT2
  - PAMB
  - EEC N2 reset
  - Idle select
- Outputs
  - Metered fuel for combustion
  - Regulated hydraulic pressure to compressor airflow control system
  - N2 reset piston position feedback to EEC
  - Bypass fuel to pump interstage
- Adjustments
  - Minimum idle trim
  - Approach idle trim
  - Takeoff trim

Fuel Control Diagram



CT 4083

EEC Trim Authority

CHARACTERISTICS

Description and Operation:

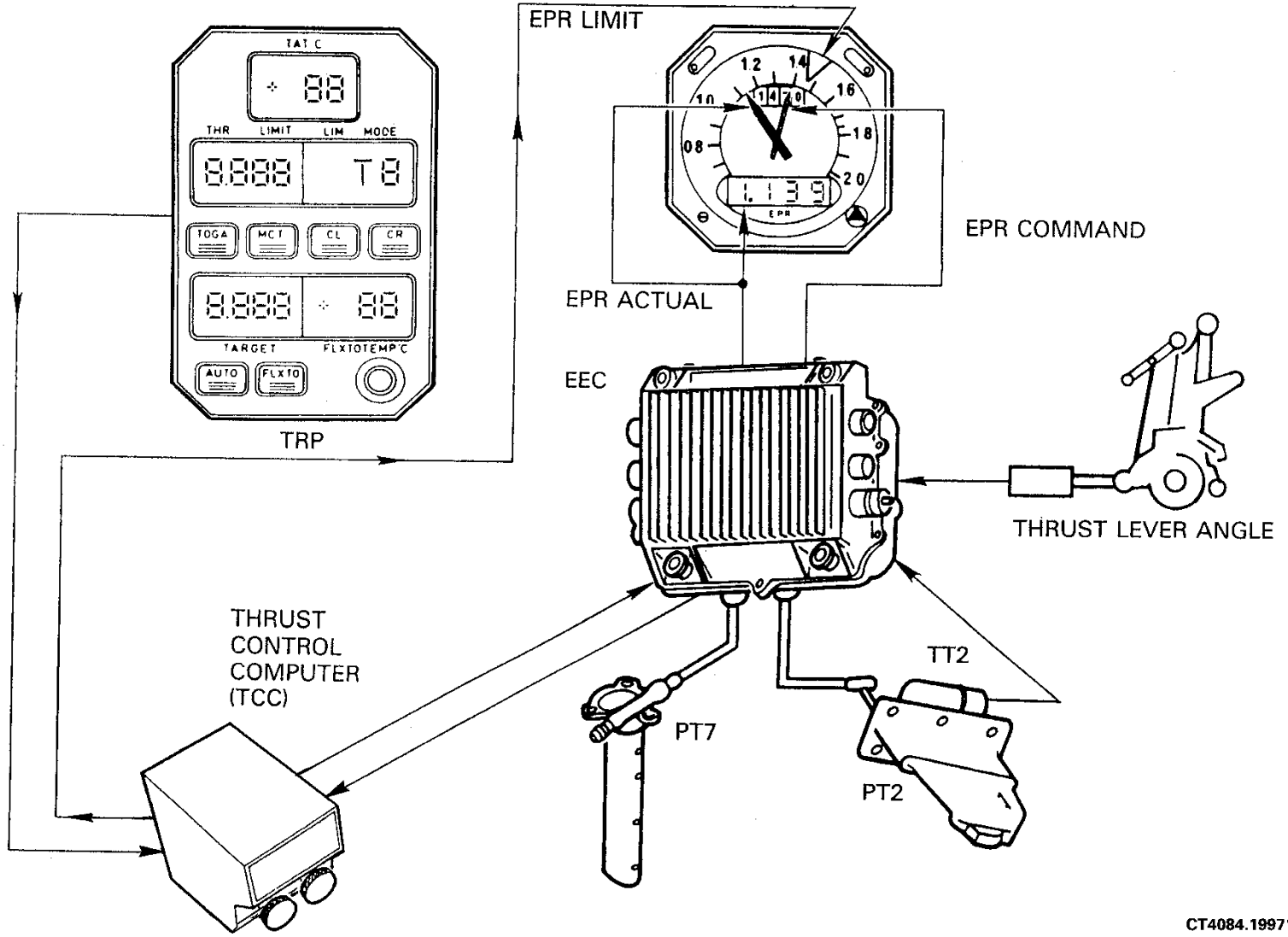
- Percent of takeoff thrust versus PLA
- Hydromechanical fuel control maximum trim schedule
- Idle
  - 40^{o} to 60^{o} PLA
  - 31^{o} to 43^{o} TLA
- Maximum forward:
  - 128.8^{o} to 134.1^{o} PLA
  - 84.3^{o} to 87.5^{o} TLA
- Authority band - 27% N2
- EEC trimmed schedule

PERMISSIVES

Description and Operation:

- EEC ON
- Inhibited to 85^{o} PLA at Mn 0

EPR Signal Processing



CT4084

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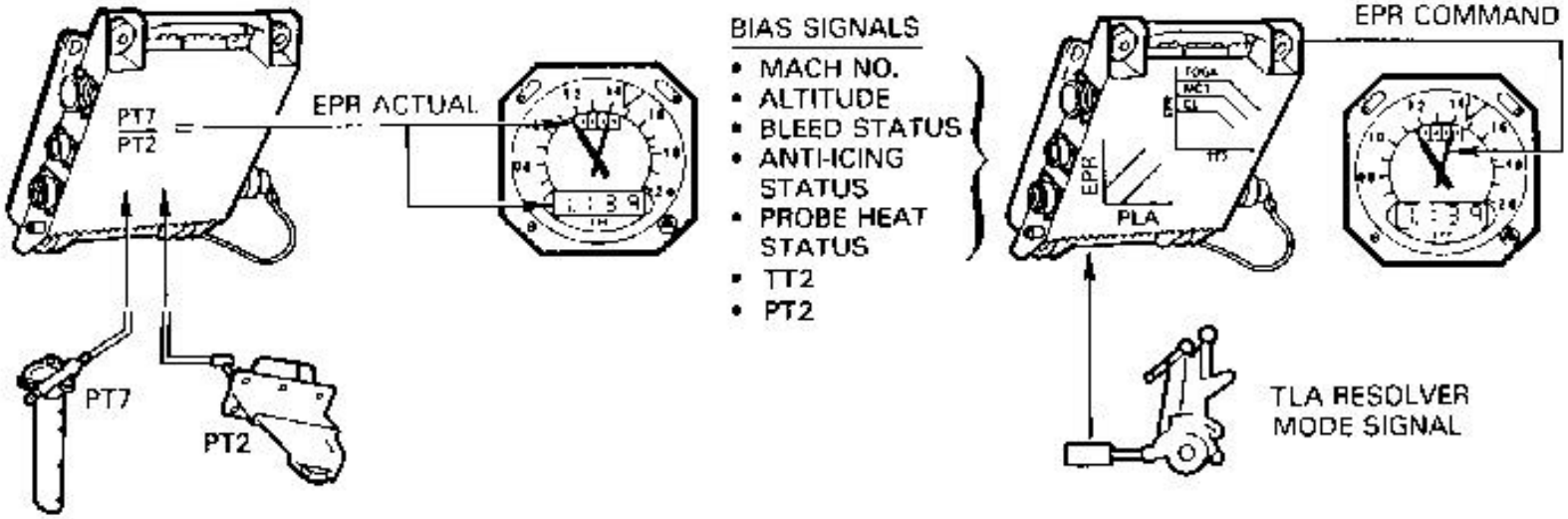
EPR Signal Processing

① EPR ACTUAL

EEC CONVERTS PRESSURE SIGNALS DIRECTLY TO ELECTRICAL SIGNAL FOR DISPLAY

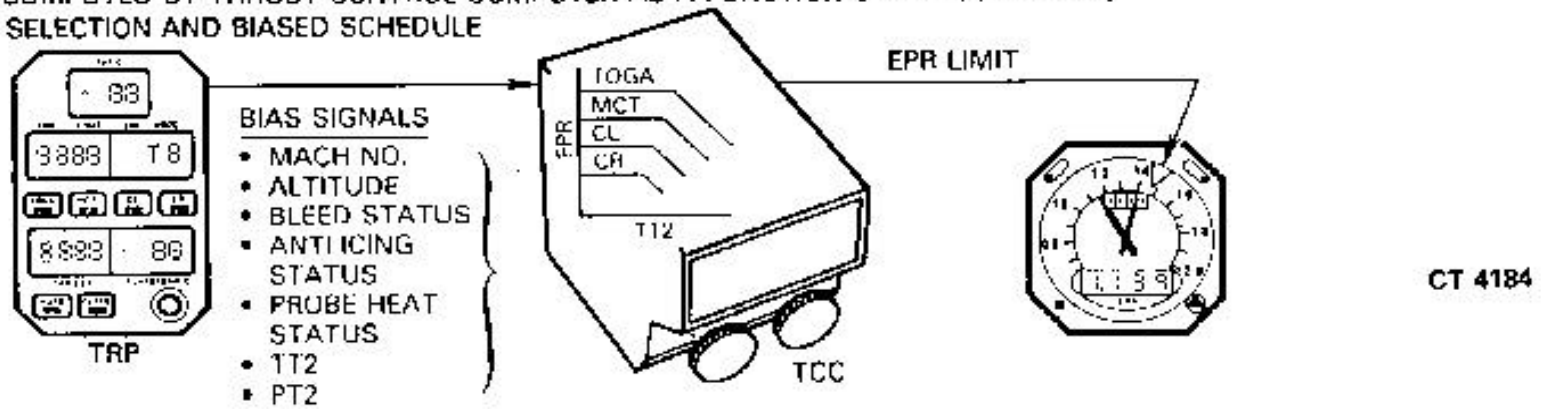
② EPR COMMAND

EEC PROCESSES SIGNAL FROM TLA RESOLVER THROUGH BIASED SCHEDULE AND TRANSMITS RESULT (EPR COMMAND) TO INDICATOR



③ EPR LIMIT

COMPUTED BY THRUST CONTROL COMPUTER AS A FUNCTION OF THRUST RATING SELECTION AND BIASED SCHEDULE



CT 4184

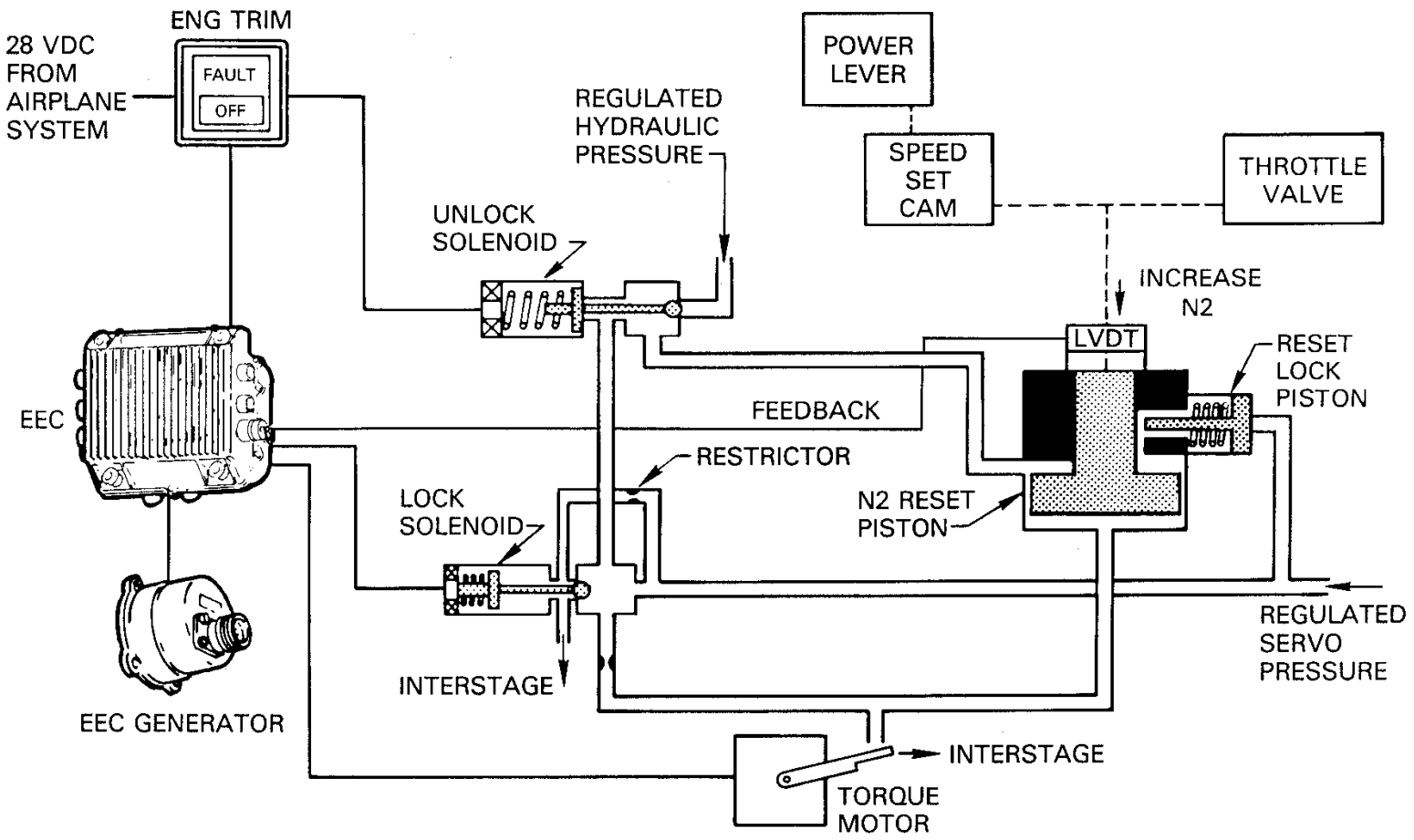
EPR Operating Mode - EEC “On”

SYSTEM COMPONENTS STATUS - EEC ON

Description and Operation:

- Engine trim switch ON
  - Not illuminated
- Power lever
  - Between idle and takeoff
- Unlock solenoid
  - De-energized
- Lock solenoid
  - Energized
- Torque motor
  - Responsive to EEC commands
- Reset lock piston
  - Unlocked
- N2 reset piston
  - Responsive to torque motor and flapper valve commands
- Linear variable differential transformer
  - Gives N2 reset piston position feedback to EEC
- Hydraulic pressures
  - Regulated hydraulic pressure: 725 - 750 psi
  - Regulated servo pressure: 135 psi above fuel control body pressure
  - Interstage pressure: 80 - 100 psi

EEC “On” Mode



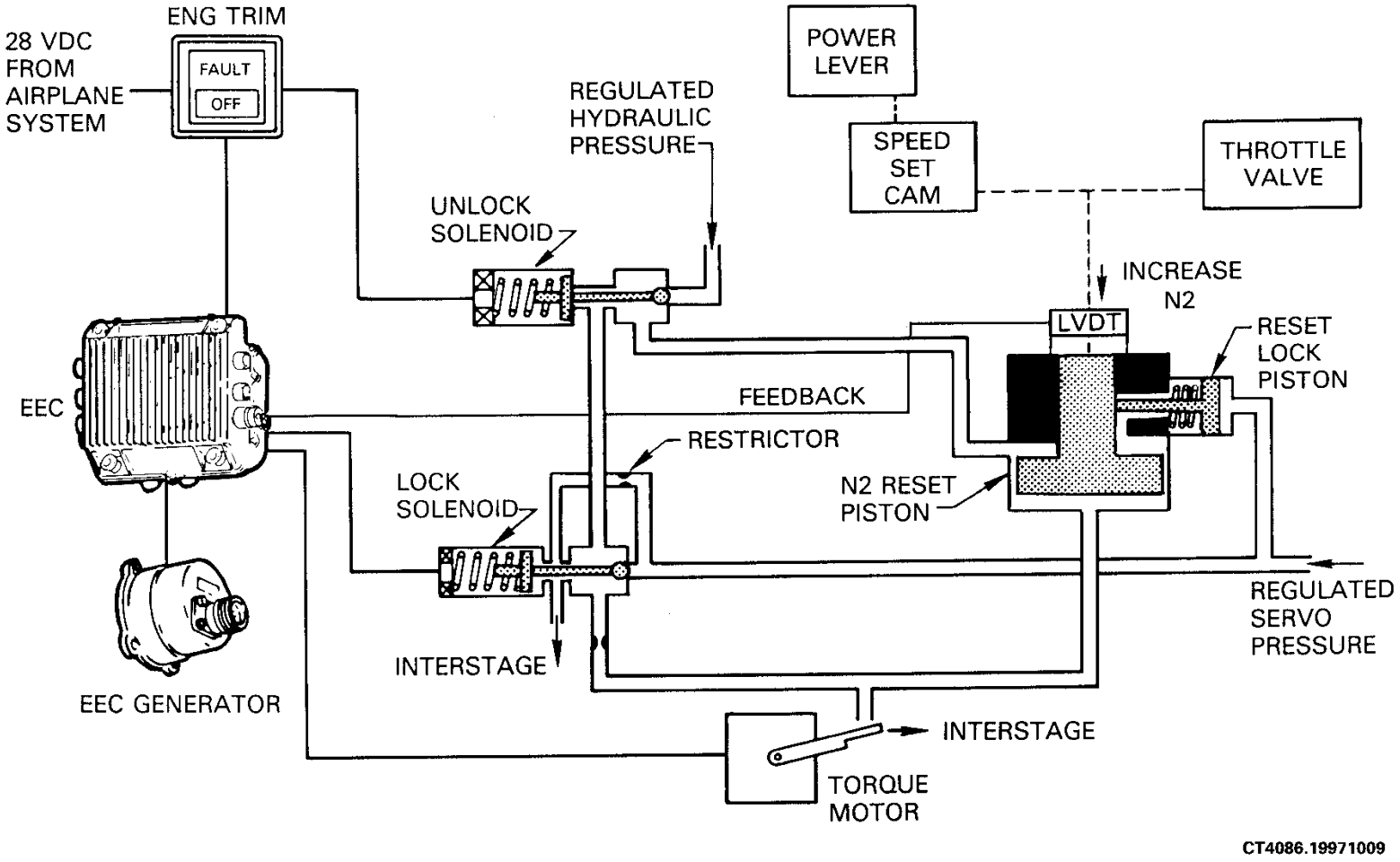
CT4085

EPR Operating Mode - EEC “Disengage” Mode

Description and Operation:

- Engine trim switch
  - FAULT illuminated
- Power lever
  - Between idle and takeoff
- Unlock solenoid
  - De-energized
- Lock solenoid
  - De-energized
- Torque motor
  - Not responsive to EEC commands
- Reset lock piston
  - Locked
- N2 reset piston
  - Locked in last EEC commanded position
- Engine operation
  - Hydromechanical control with reset at last EEC commanded position

EEC “Disengage” Mode



EEC “DISENGAGE” MODE

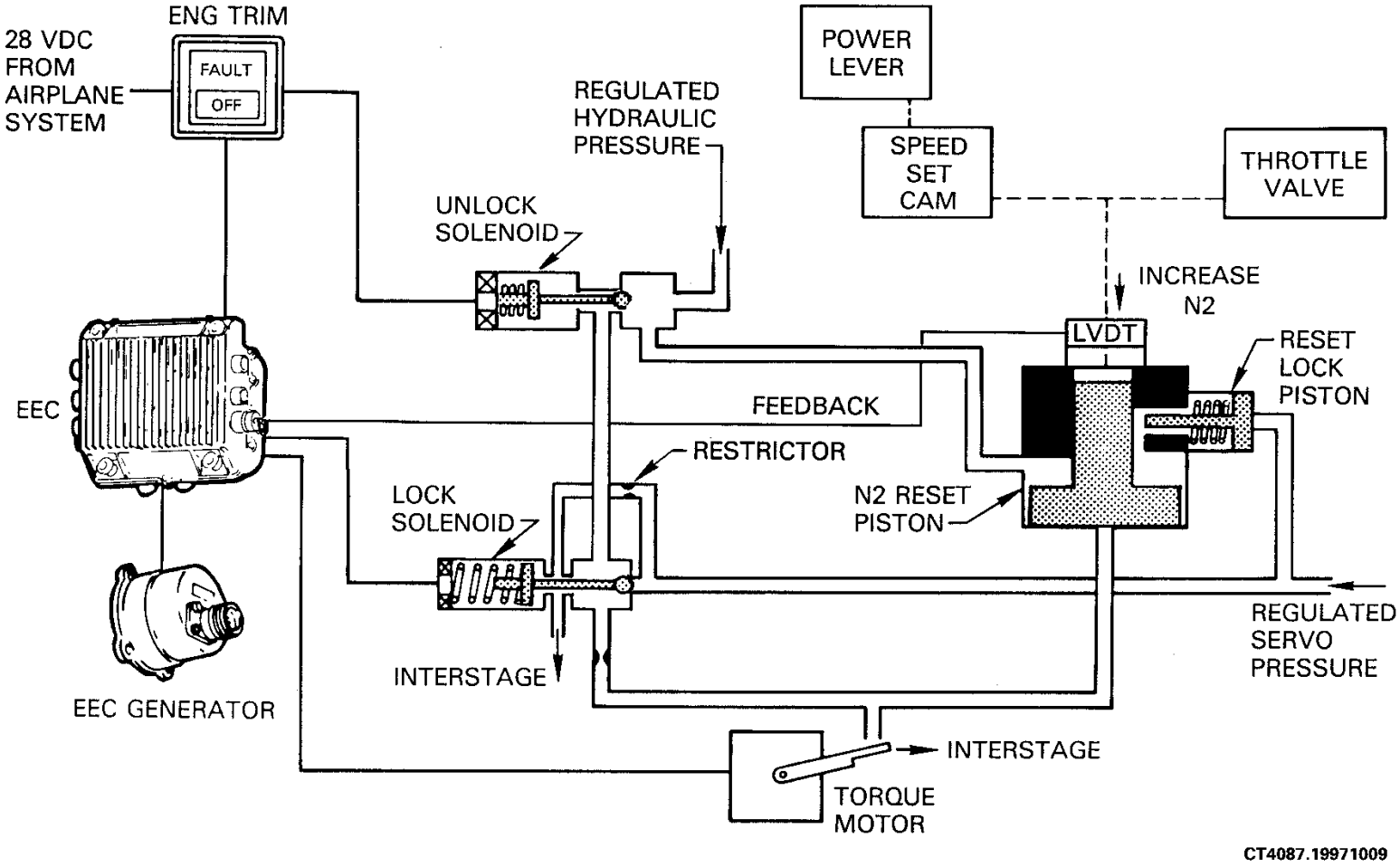
CT4086

EPR Operating Mode - EEC “Off” Mode

Description and Operation:

- Engine trim switch
  - OFF illuminated
- Power lever
  - Retarded
- Unlock solenoid
  - Energized
- Lock solenoid
  - De-energized
- Torque motor
  - Disabled
- Reset lock piston
  - Unlocked
- N2 reset piston
  - Full increase N2 position
- Engine operation
  - Full hydromechanical fuel control authority

EEC “Off” Mode



EEC “OFF” MODE

CT4087

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COMPRESSOR AIRFLOW CONTROL SYSTEM (CACS)

Compressor Airflow Control System

GENERAL

Purpose:

- The Compressor Airflow Control System (CACS) ensures compressor stability during engine starting, off-design operating conditions, and reverse thrust operation.

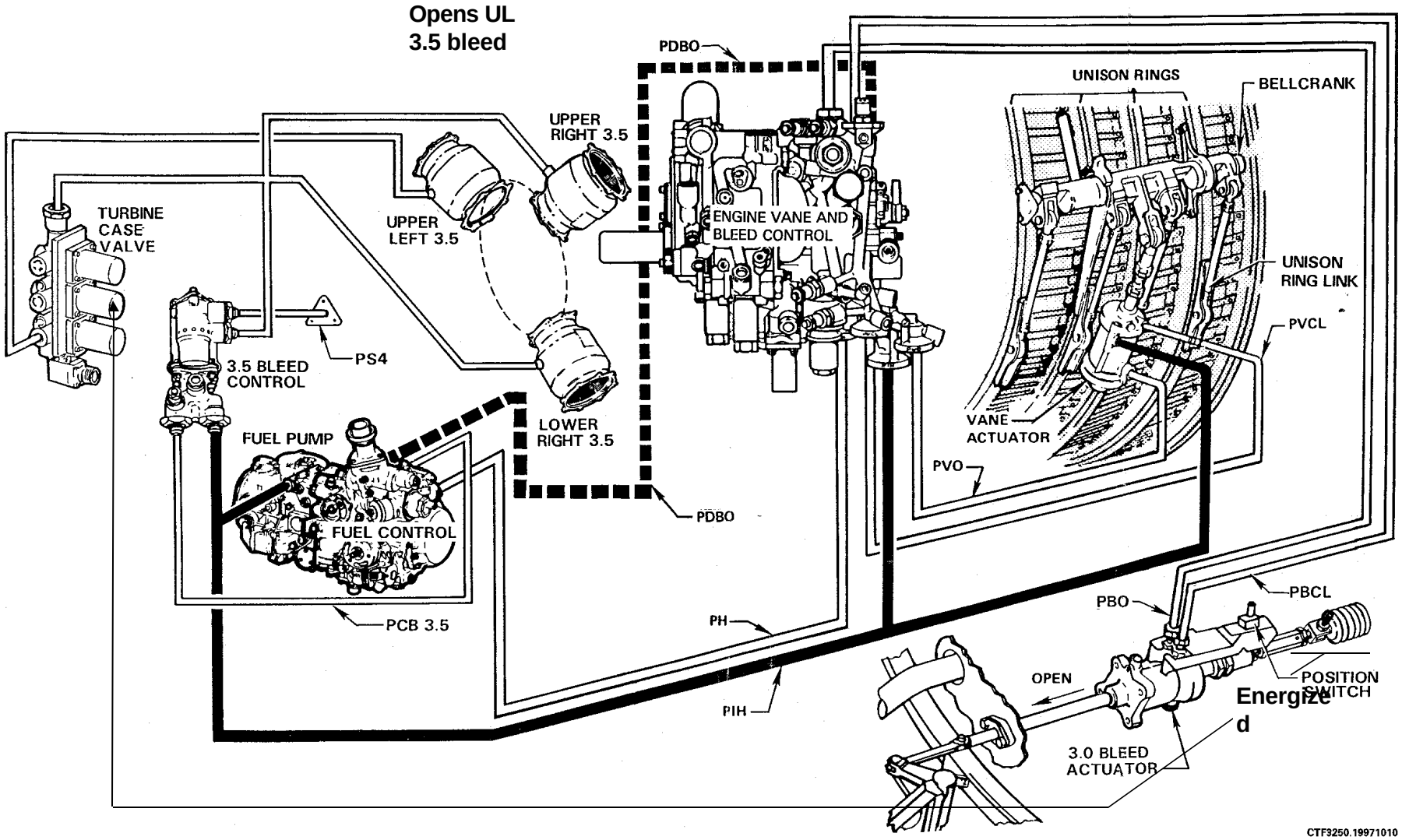
Subsystems:

- Bleed system
  - Start bleeds
  - Tandem bleed system
  - Reverser actuated bleed system
- Variable stator vanes system

Components:

- Fuel pump
- Hydromechanical fuel control (HMC)
- Engine vane and bleed control
- Vane actuator
- Bellcrank
- Mach probes
- 3.5 bleed valves
- 3.5 bleed control valve
- 3.0 bleed actuator and feedback cable
- Turbine case valve
- 3.0 bleed position switch

Compressor Airflow Control System

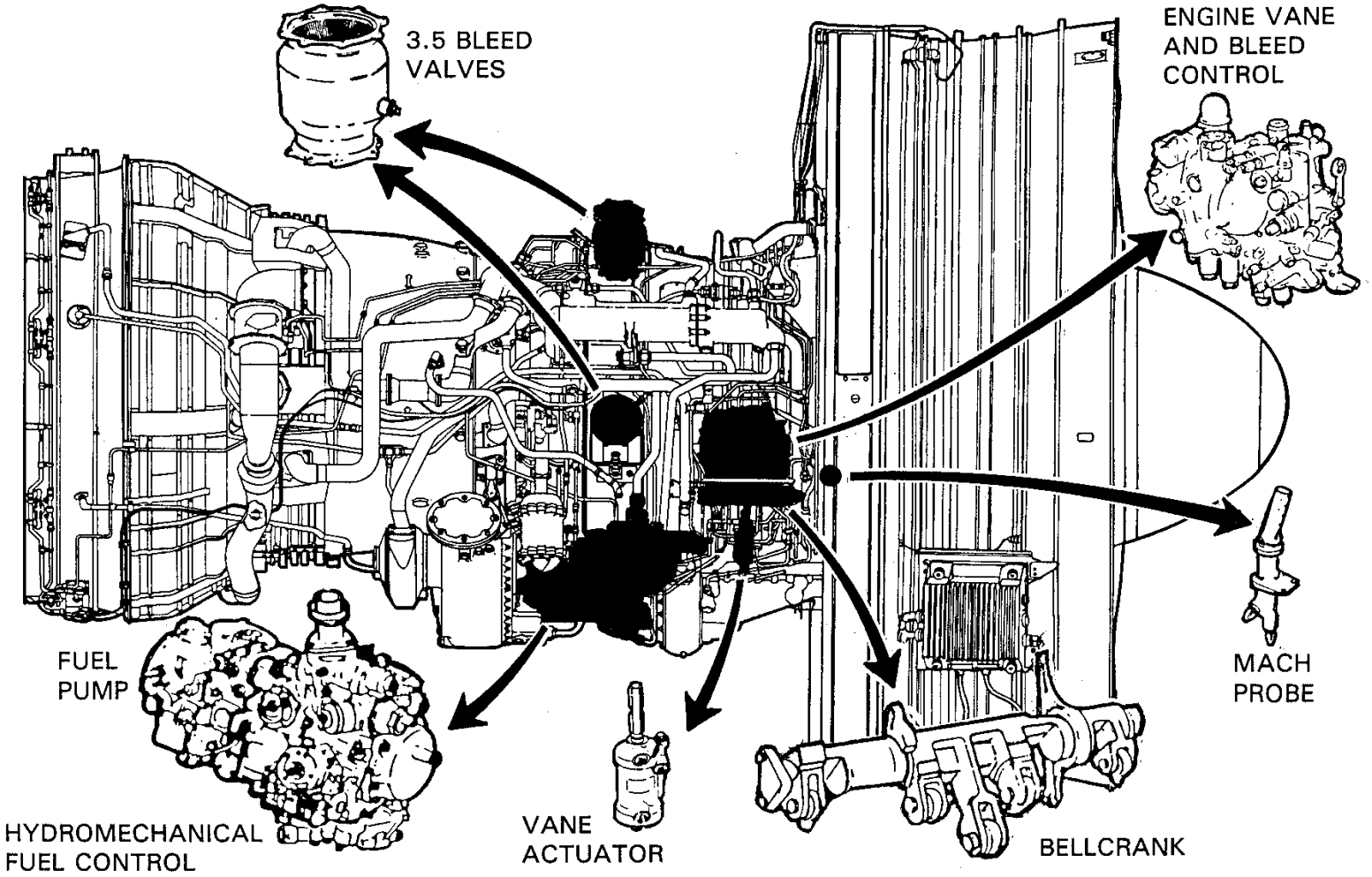


CT3250

CACS Components - Right Side

- Mach probe
  - Mounted on the intermediate case rear face at the 4:00 position (electrically anti-iced)
- Engine vane and bleed control
  - Mounted on the high pressure compressor case at the 3:00 position
- Bellcrank
  - Mounted just above the variable vane actuator on the high pressure compressor at the 4:00 position
- Variable vane actuator
  - Mounted on the high pressure compressor at the 4:00 position
- Fuel control
  - Mounted on the fuel pump found on the main gearbox (forward right hand side)
- Fuel pump
  - Mounted on the main gearbox (forward right hand side)
- 3.5 bleed valves
  - Mounted on the high pressure compressor at the 1:00 and 3:00 positions
- Unison rings
  - Mounted around (360^{o}) the high pressure compressor case
- Vane feedback link
  - Connects the bellcrank to the vane feedback lever on the EVBC
- 3.0 bleed feedback cable
  - Attaches to the 3.0 bleed feedback lever on the EVBC

CACS Components - Right Side



CT3625.19971009

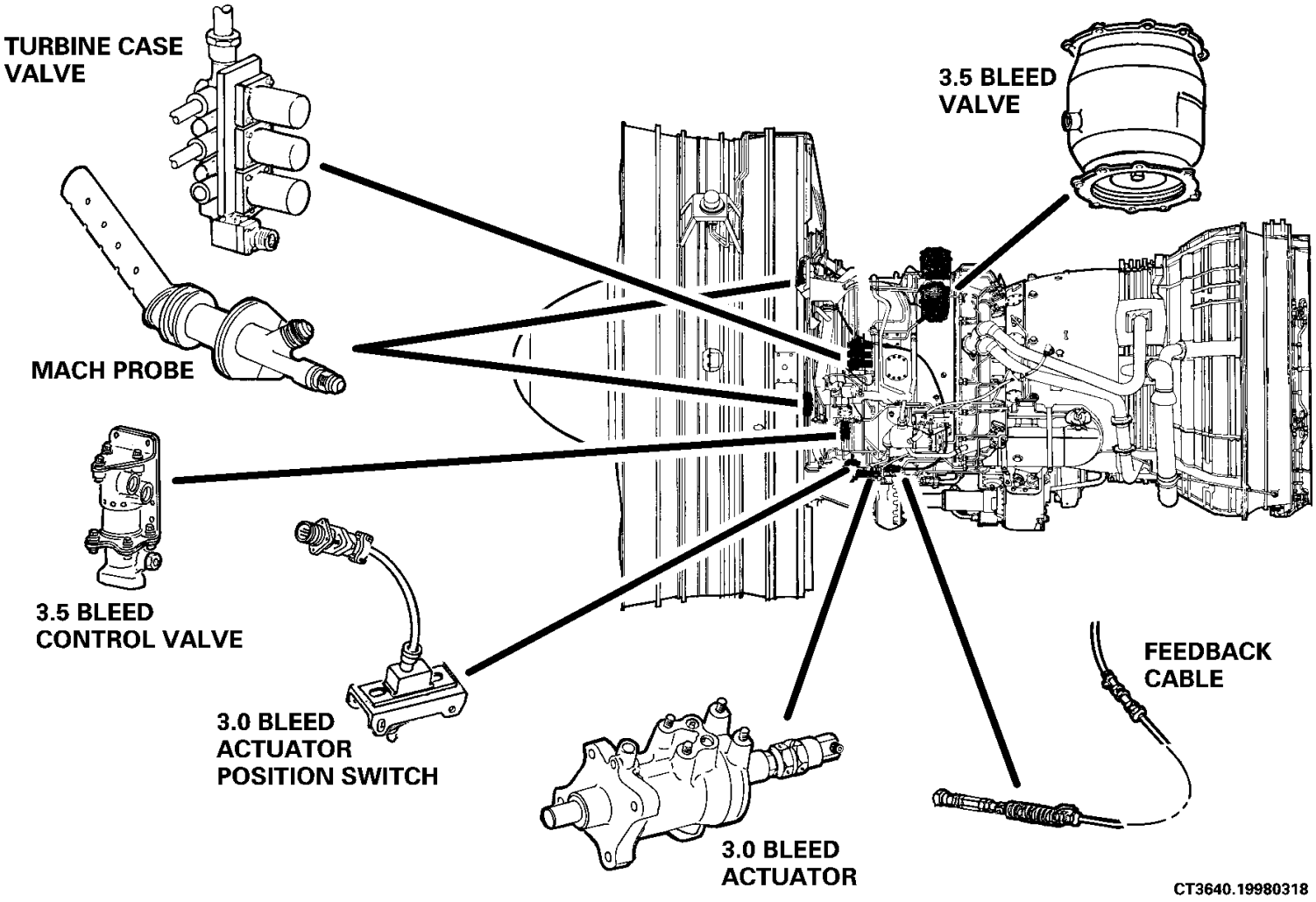
CT3625

CACS Components - Left Side

Engine - Left Side:

- 3.0 bleed actuator and feedback cable
  - Mounted on the intermediate case rear flange at the 7:00 position
  - Cable connects to the EVBC on the right side of the engine
- 3.0 bleed actuator position switch
  - Mounted on the aft end of the 3.0 bleed actuator
- 3.5 bleed control valve
  - Mounted on the high pressure compressor at the 8:00 position
- Mach probes
  - Mounted on the intermediate case rear flange at the 8:00 and 11:00 positions (11:00 position electrically anti-iced)
- Turbine case valve
  - Mounted on the high pressure compressor case at the 9:00 position
- 3.5 bleed valve
  - Mounted on the high pressure compressor case at the 11:00 position

CACS Components - Left Side



CACS COMPONENTS - LEFT SIDE

CT3640

3.5 Start Bleed Subsystem

GENERAL

Purpose:

- The 3.5 start bleed subsystem improves engine start characteristics and prevents compressor surge.

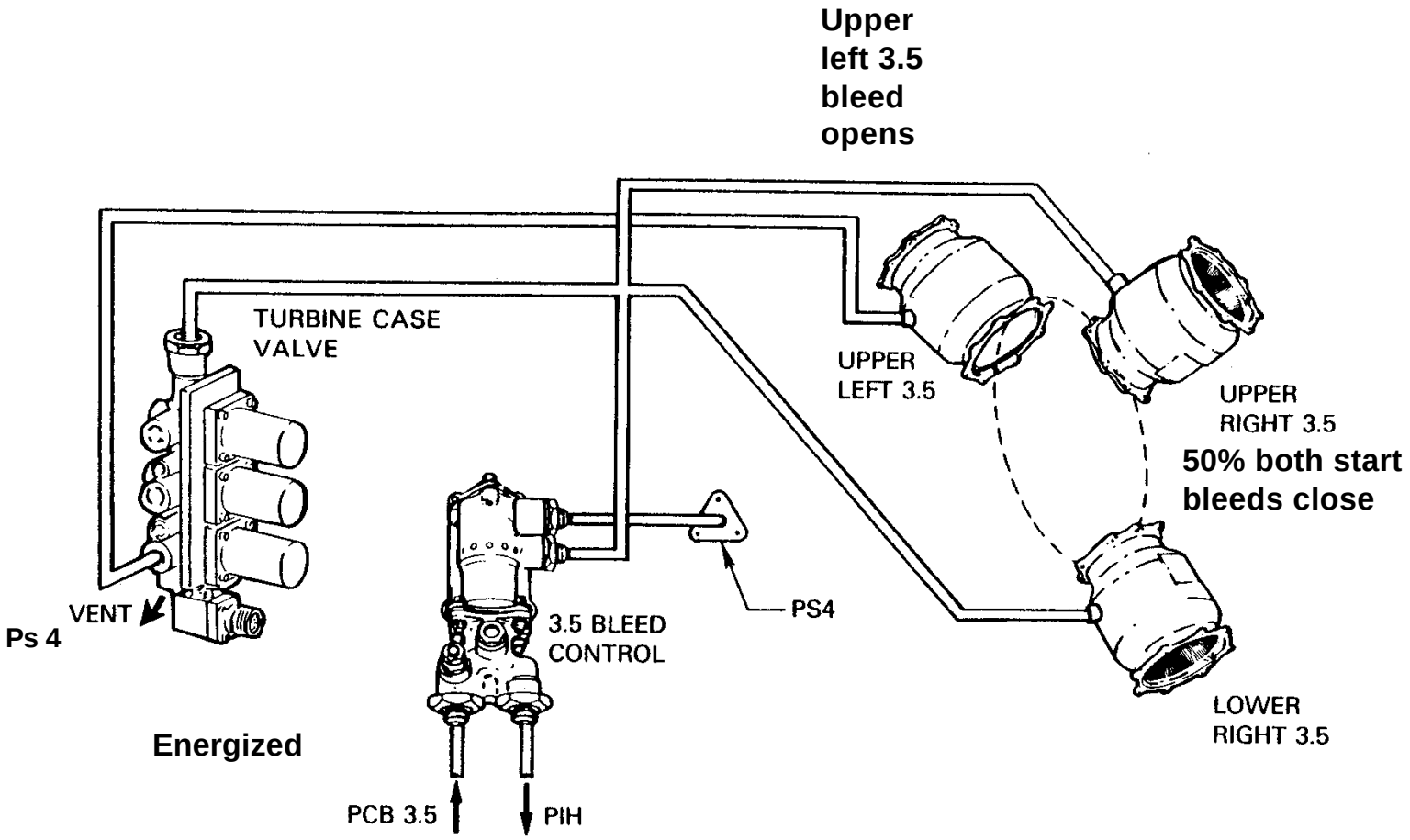
Components:

- 3.5 bleed control valve
- Turbine case valve
- 3.0 bleed actuator position switch
- 3.5 bleed valves (3)

Description and Operation:

- The 3.5 start bleed valves are spring-loaded open at engine shutdown and up to 50% N2 during start.
- At 50% N2, the PCB3.5 hydraulic signal from the fuel control unit opens the 3.5 bleed control valve permitting PS4 to pneumatically close the upper right and lower right 3.5 bleed valves (on ground).
- The upper left 3.5 bleed valve stays open since the 3.0 bleed actuator piston switch energizes the bottom turbine case solenoid valve, venting the upper left 3.5 bleed valve pressure line to keep it open.
- The 3.0 bleed valve is full open during start.

3.5 Start Bleeds



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CT4343

3.5 Bleed Control Valve

Purpose:

- The 3.5 bleed control valve controls the flow of PS4 to the upper right and lower right 3.5 bleed valves and to the turbine case valve..

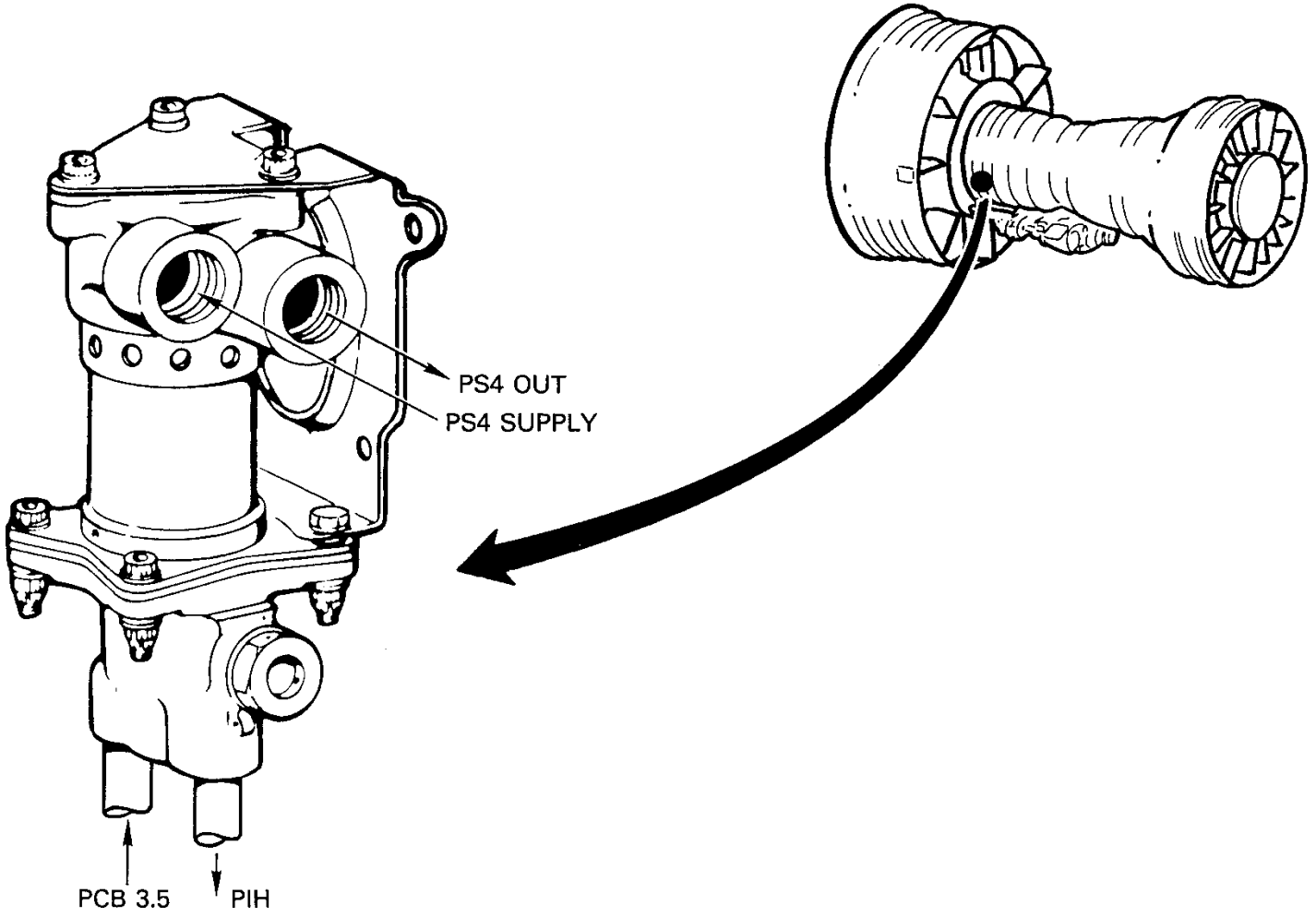
Location:

- The 3.5 bleed control valve is mounted on the high pressure compressor case at the 8:00 position

Description and Operation:

- Inputs
  - PS4 (from the diffuser case at the 10:30 position)
  - PCB3.5 (from the hydromechanical fuel control at 50% N2)
- Outputs
  - PS4 to the upper right and lower right 3.5 bleed valves
  - PS4 to the turbine case valve
  - PIH to the engine-driven fuel pump interstage

3.5 Bleed Control Valve



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CT4093

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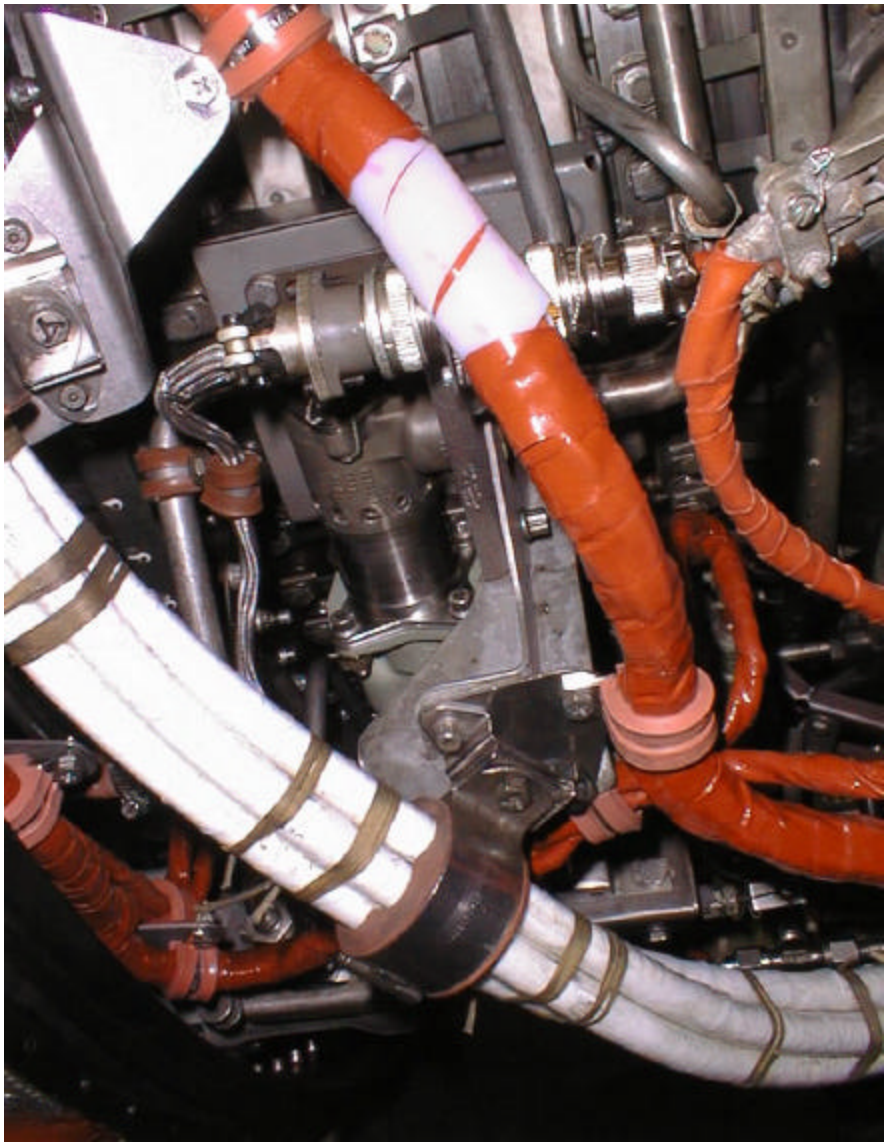
3.5 Bleed Control Valve



Turbine Case Valve

Purpose:

- The turbine case valve sends PS4 to the upper left 3.5 bleed valve.

Location:

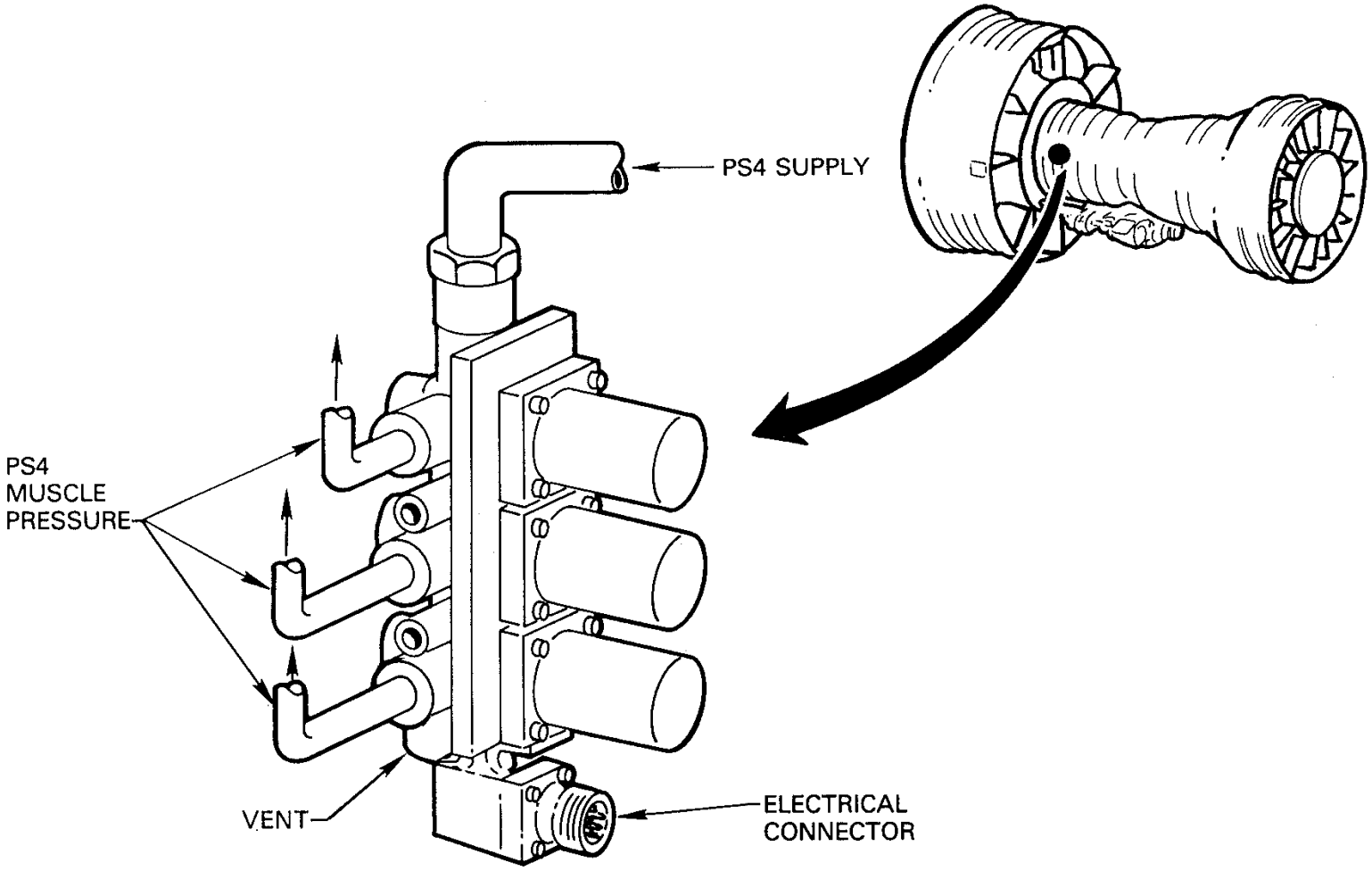
- The turbine case valve is mounted on the high pressure compressor case at the 9:00 position

Description and Operation:

- Lower solenoid energized on ground to stop flow of PS4 to upper left 3.5 bleed valve to keep the bleed open.
- Lower solenoid de-energized to permit Ps4 pressure to close ULH 3.5 bleed valve:
  - As the 3.0 bleed closes (on ground).
  - In flight.

Turbine Case Valve

Replaces linear directional control valve



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CT4376

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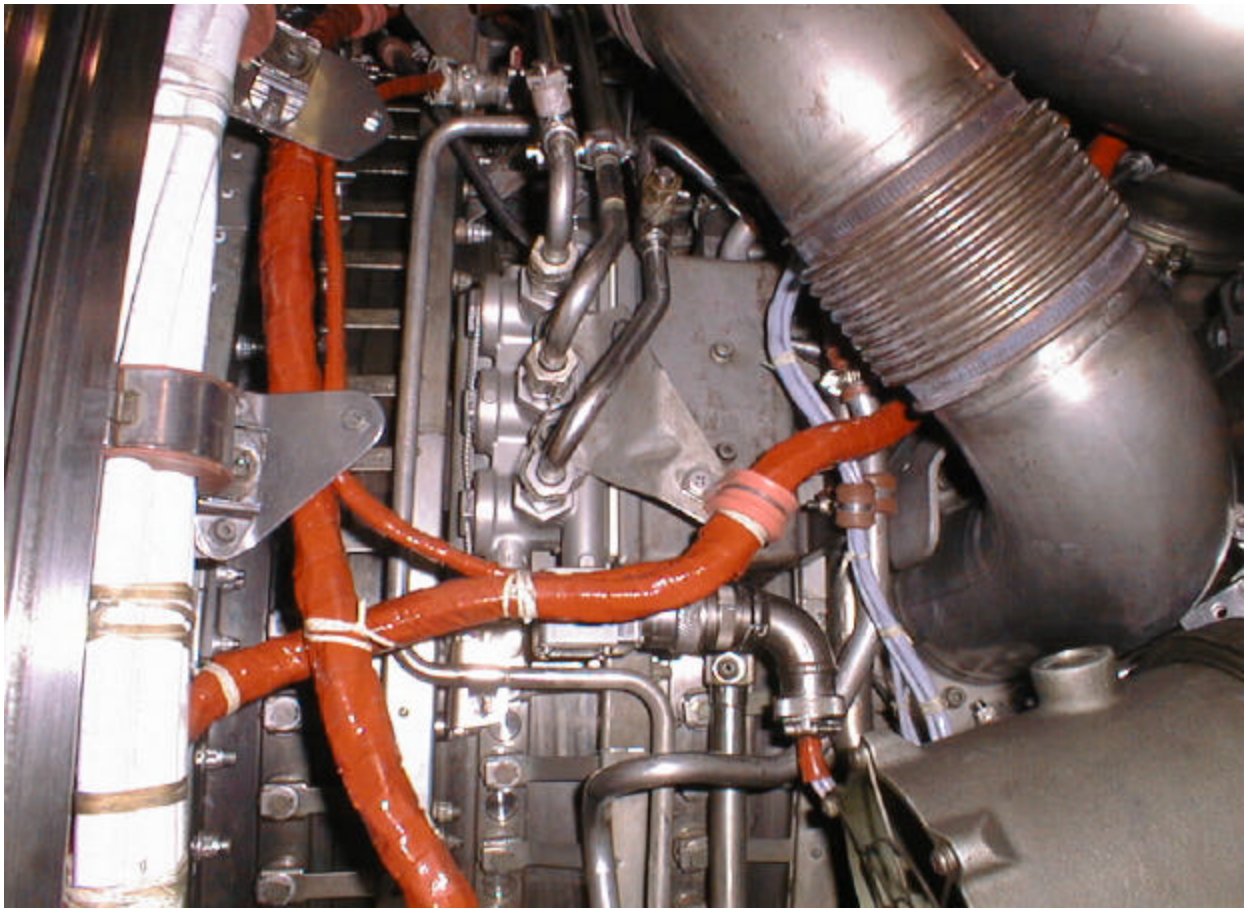
Turbine Case Valve



3.5 Bleed Valves

Purpose:

- The 3.5 bleed valves are used to bleed off 9th stage air during:
  - Start.
  - Reverse thrust operation.

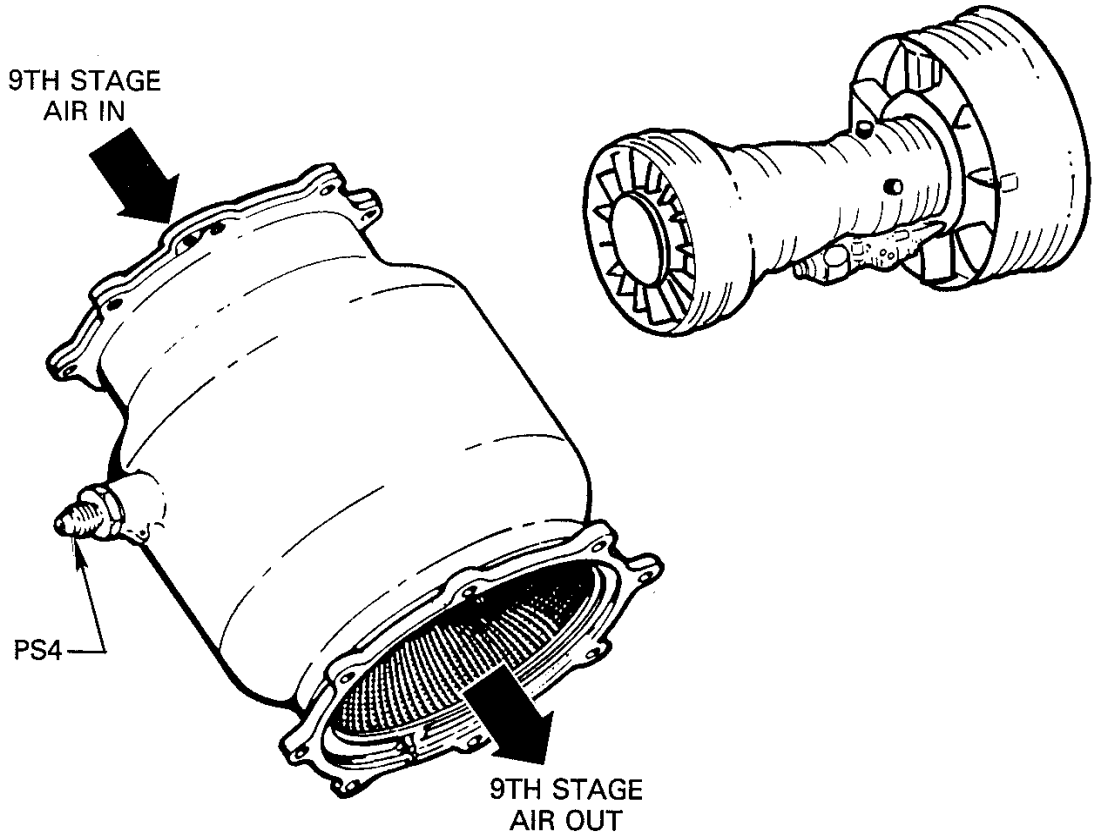
Location:

- The 3.5 bleed valves are mounted on the high pressure compressor case at the 1:00, 3:00, and 11:00 positions.

Description and Operation:

- Two positions
  - Spring-loaded open
  - Pneumatically closed
- 10 psig maximum pressure to close 3.5 bleed valves

3.5 Bleed Valve



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CT4096

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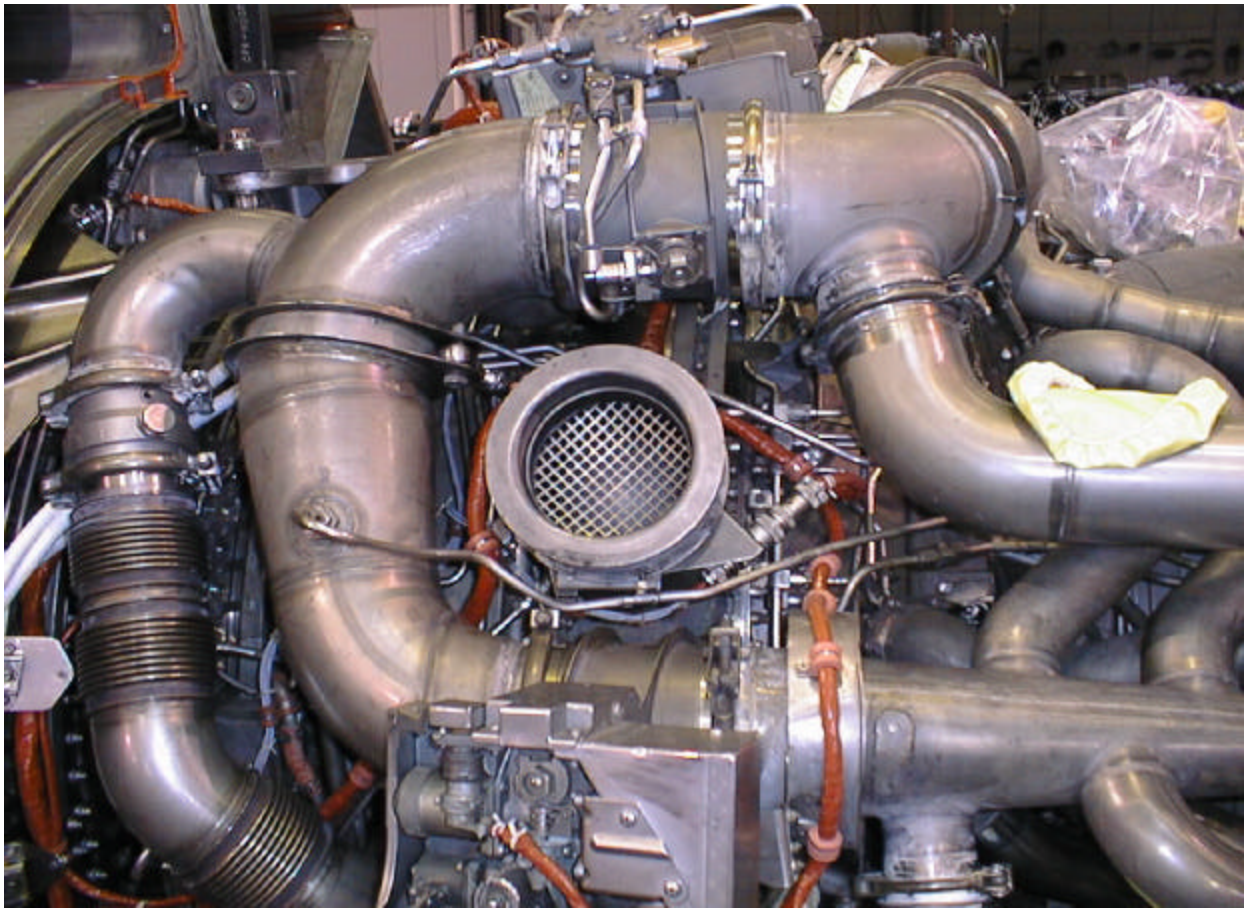
3.5 Bleed Valve



3.0 Modulating Bleed

Purpose:

- The 3.0 modulating bleed ensures compressor stability during start, low thrust operation, deceleration, and reverse thrust operation.

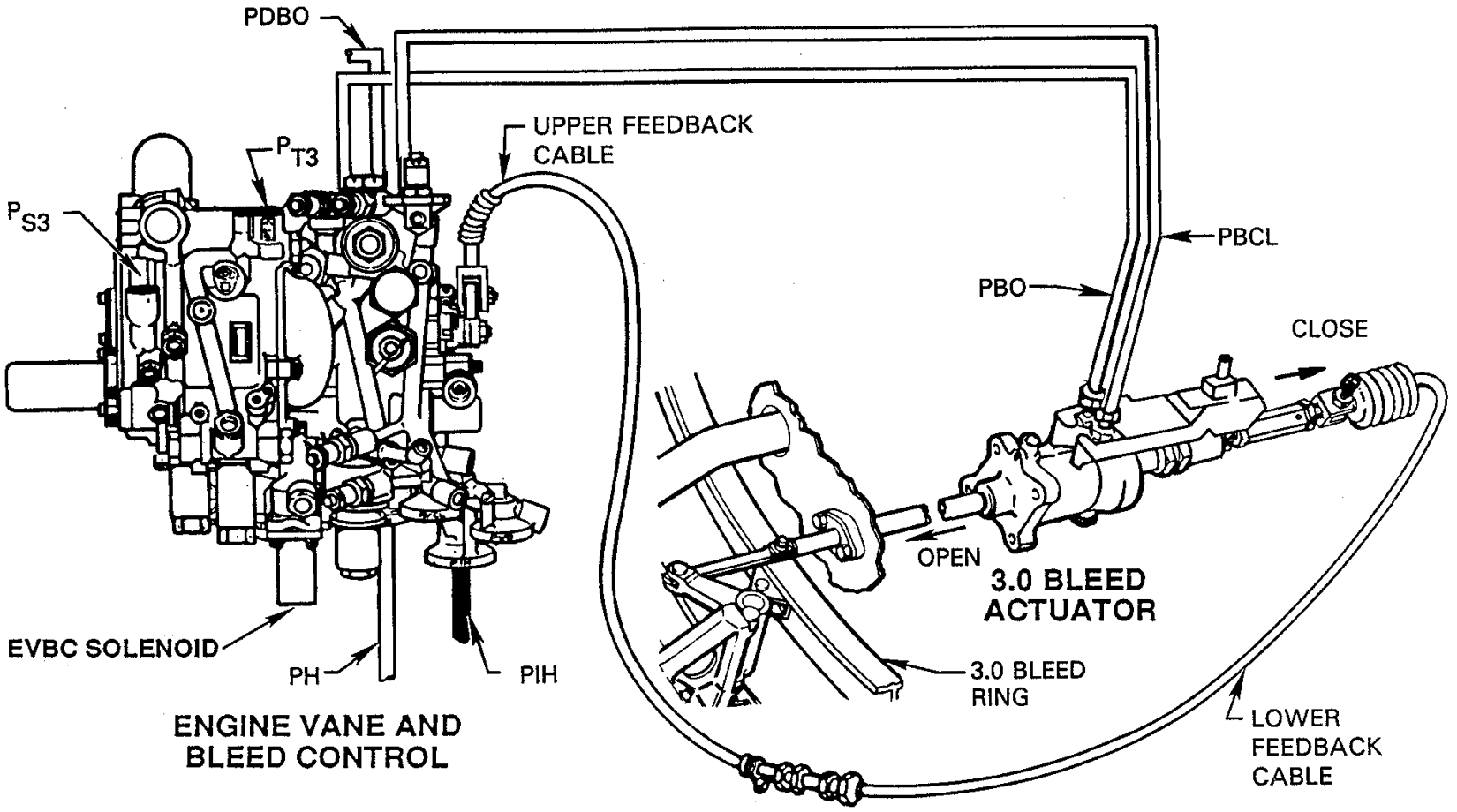
Components:

- EVBC
- 3.0 bleed actuator
- 3.0 bleed ring
- 3.0 bleed actuator feedback cable
- MACH probes

Description and Operation:

- Correct 3.0 bleed ring position is determined by the EVBC, as a function of low pressure compressor discharge total and static pressure. As a result of the total and static pressure relationship, the EVBC will provide high pressure fuel to a double acting 3.0 bleed ring actuator causing the 3.0 bleed ring to close, open, or modulate. The feedback cable closes the EVBC request / response loop.
- 3.0 bleed actuator position is sensed by the 3.0 bleed actuator position switch.

3.0 Modulating Bleed



CT4339.19971009

CT4339

Tandem Bleed Subsystem

GENERAL

Purpose:

- The tandem bleed subsystem is used to stop compressor surge.

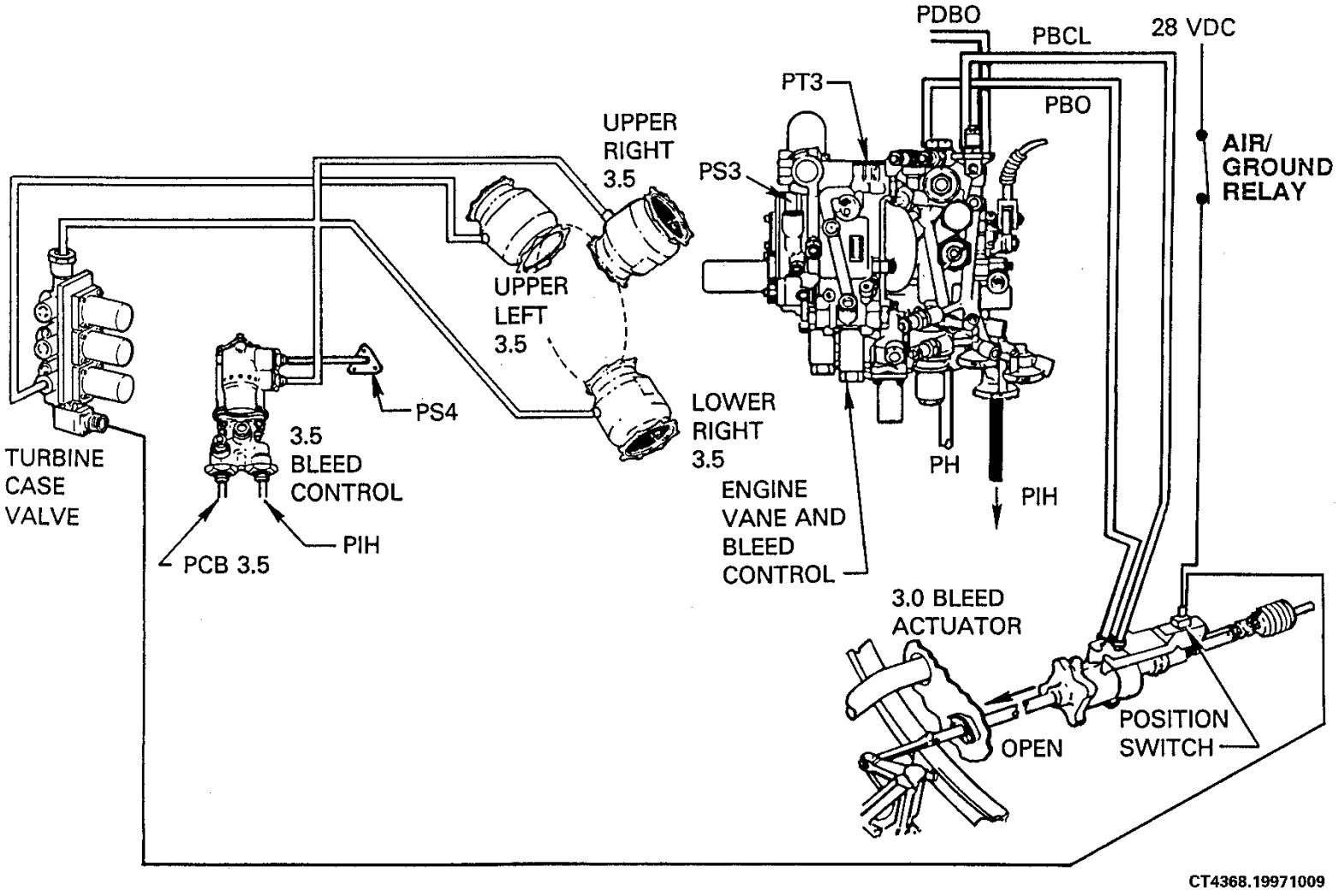
Components:

- 3.0 bleed valve and actuator
- 3.0 bleed actuator position switch and tripper
- EVBC
- Upper left hand 3.5 bleed valve
- 3.5 bleed control valve
- Turbine case valve
- MACH probes
- Aircraft air / ground relay

Description and Operation:

- Upon acceleration from idle, the remaining open upper left hand 3.5 bleed valve and modulating 3.0 bleed valve both close; valves open again upon deceleration.
- Tandem feature is removed at liftoff - thus all three (3) 3.5 bleed valves remain closed in flight

Tandem Bleed Subsystem



CT4368

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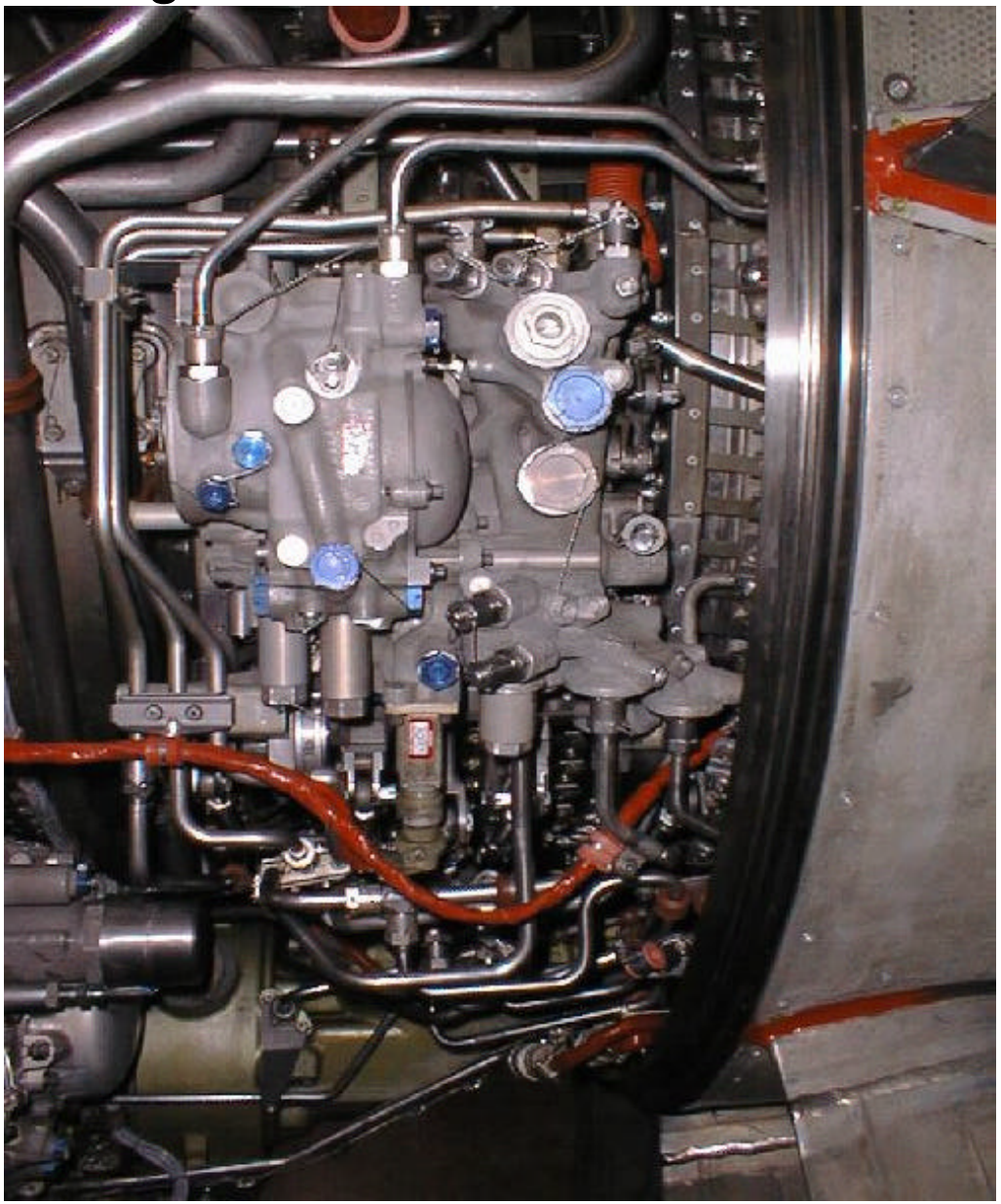
Engine Vane and Bleed Control



Tandem Bleed Subsystem - Components

ENGINE VANE AND BLEED CONTROL (EVBC)

Purpose:

- The EVBC controls the modulating 3.0 bleed actuator and variable vanes system actuator.

Location:

- The EVBC is found on the high pressure compressor case at the 3:00 position.

Description and Operation:

- Inputs
  - Pneumatic
    - Pt3 and Ps3 converted to station 3 MACH number as a function of: $\frac{Pt3 - Ps3}{Pt3}$
  - Hydraulic
    - PH - servo and muscle pressure
    - PDBO - rapid deceleration logic
  - Electrical
    - 28 VDC
    - EVBC solenoid valve
      - Energized on ground during reverse thrust operation; de-energized in flight
  - Mechanical
    - 3.0 bleed actuator feedback cable
    - Variable vanes bellcrank feedback rod
- Outputs
  - Hydraulic
    - PBO - bleed open pressure
    - PBCL - bleed close pressure
    - PVO - vanes open pressure
    - PVCL - vanes close pressure
    - PIH - interstage hydraulic pressure
- Filter
  - Filters PH servo fuel
  - 40 micron disposable paper
- Trim Adjusters
  - Vane rate, vane position and 3.0 bleed position

MACH PROBES

Purpose:

- Mach probes are used to sense Pt3 and Ps3.

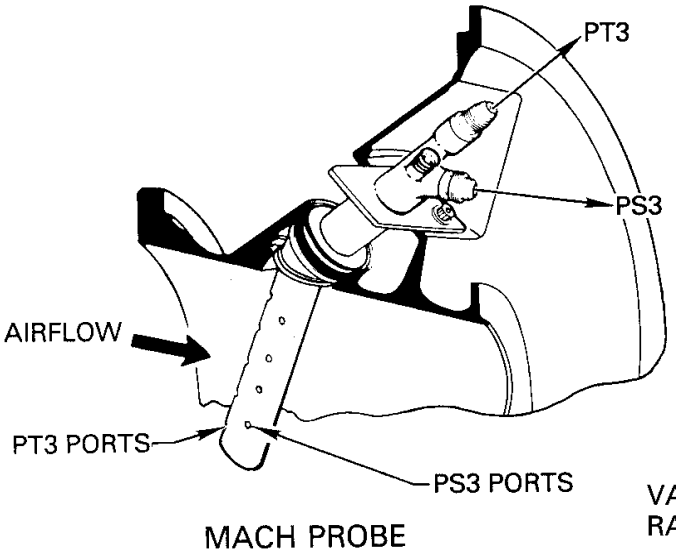
Location:

- The Mach probes are located on the intermediate case at the 4:00, 8:00, and 11:00 positions.

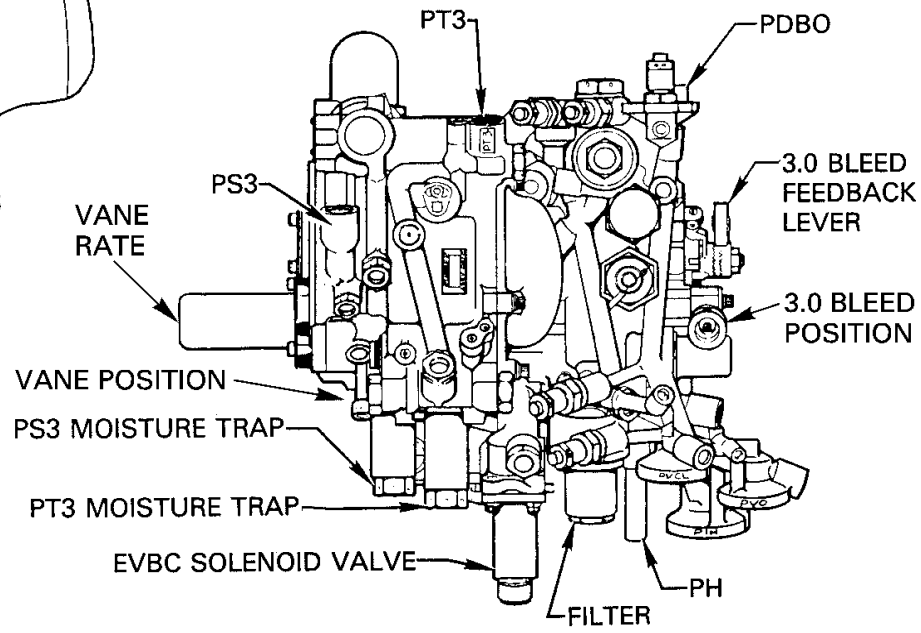
Description and Operation:

- Sense radial and circumferential pressure profile
- 4:00 and 11:00 probes electrically anti-iced when engine is running
  - 115 V / 400Hz, 100 watts
- Two-section manifolds with moisture traps

Mach Probe and EVBC



MACH PROBE



ENGINE VANE AND BLEED CONTROL

CT4008.19980318

CT4008

3.0 Modulating Bleed Subsystem - Components

3.0 BLEED ACTUATOR

Purpose:

- The 3.0 bleed actuator is used to hydromechanically position the 3.0 bleed ring.

Location:

- The 3.0 bleed actuator is found on the intermediate case at the 7:00 position.

Description and Operation:

- Double acting hydraulic actuator
- 0 - 1.89 inches displacement
- Displaced by fuel from the EVBC
- Close port has a restrictor-check valve and filter screen

3.0 BLEED ACTUATOR POSITION SWITCH AND SWITCH TRIPPER

Purpose:

- The 3.0 bleed actuator position switch and switch tripper actuates the upper left hand 3.5 bleed valve operation in relation to the 3.0 bleed actuator position.

Location:

- The 3.0 bleed actuator position switch and switch tripper are located on the aft end of the 3.0 bleed actuator.

Description and Operation:

- Switch tripper cam translates with the 3.0 bleed actuator rod
- Switch signals upper left hand 3.5 bleed valve to close on acceleration and reopen on deceleration (on ground)
- Switch actuation point adjustable
- Air / ground logic ensures upper left hand 3.5 bleed valve remains closed in flight
- Transducer brackets provide for 3.0 bleed position transducer mounting

3.0 BLEED RING

Purpose:

- Hydromechanically positions the 3.0 bleed ring uncovers or covers bleed slots in the fan exit case to control the bleed of 3.0 air into the fan duct.

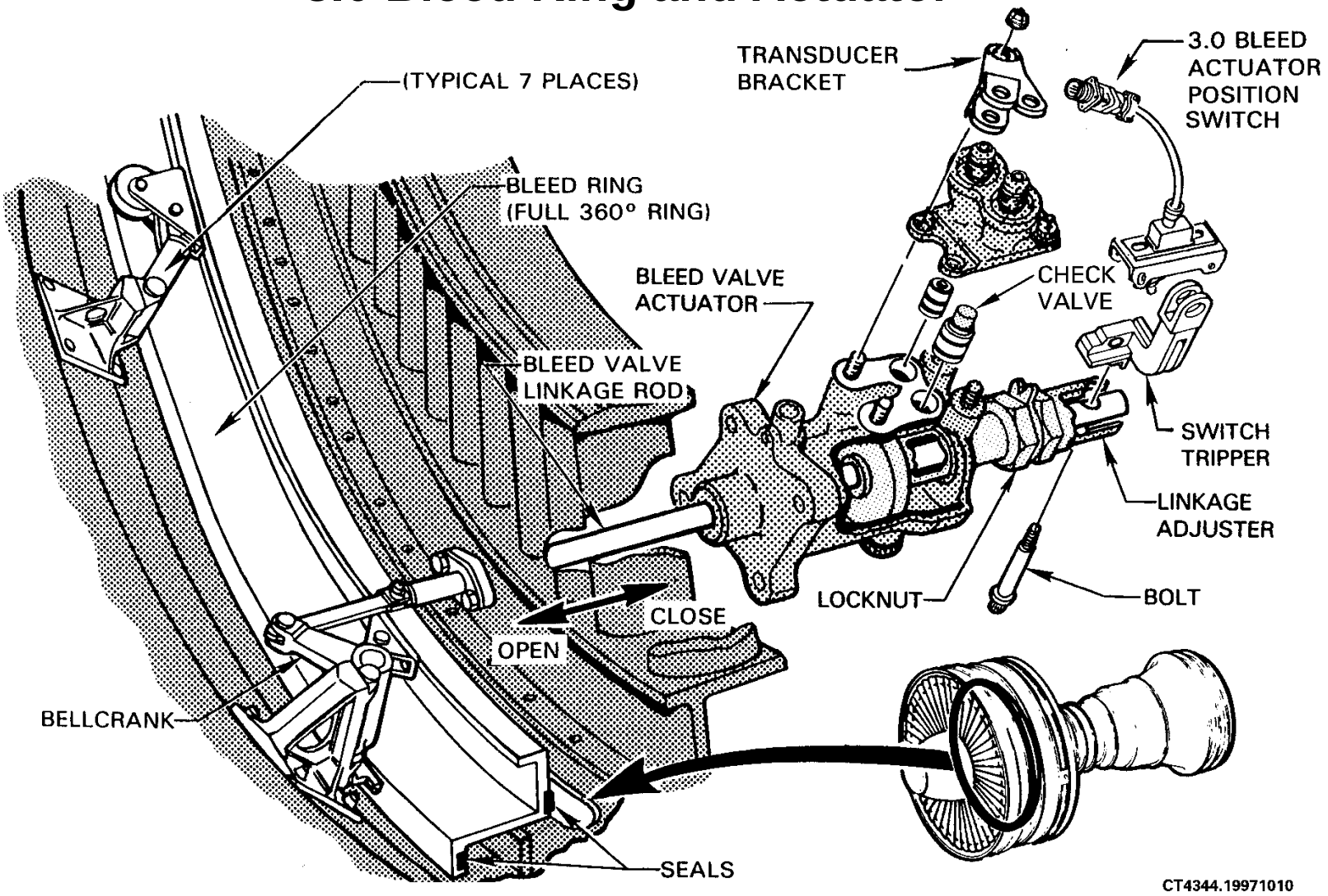
Location:

- The 3.0 bleed ring is found in the fan exit case.

Description and Operation:

- Modulating 360^{o} ring
- Rubber seals - front and rear faces
- Rotates and translates
- Guided by bellcranks

3.0 Bleed Ring and Actuator



CT4344

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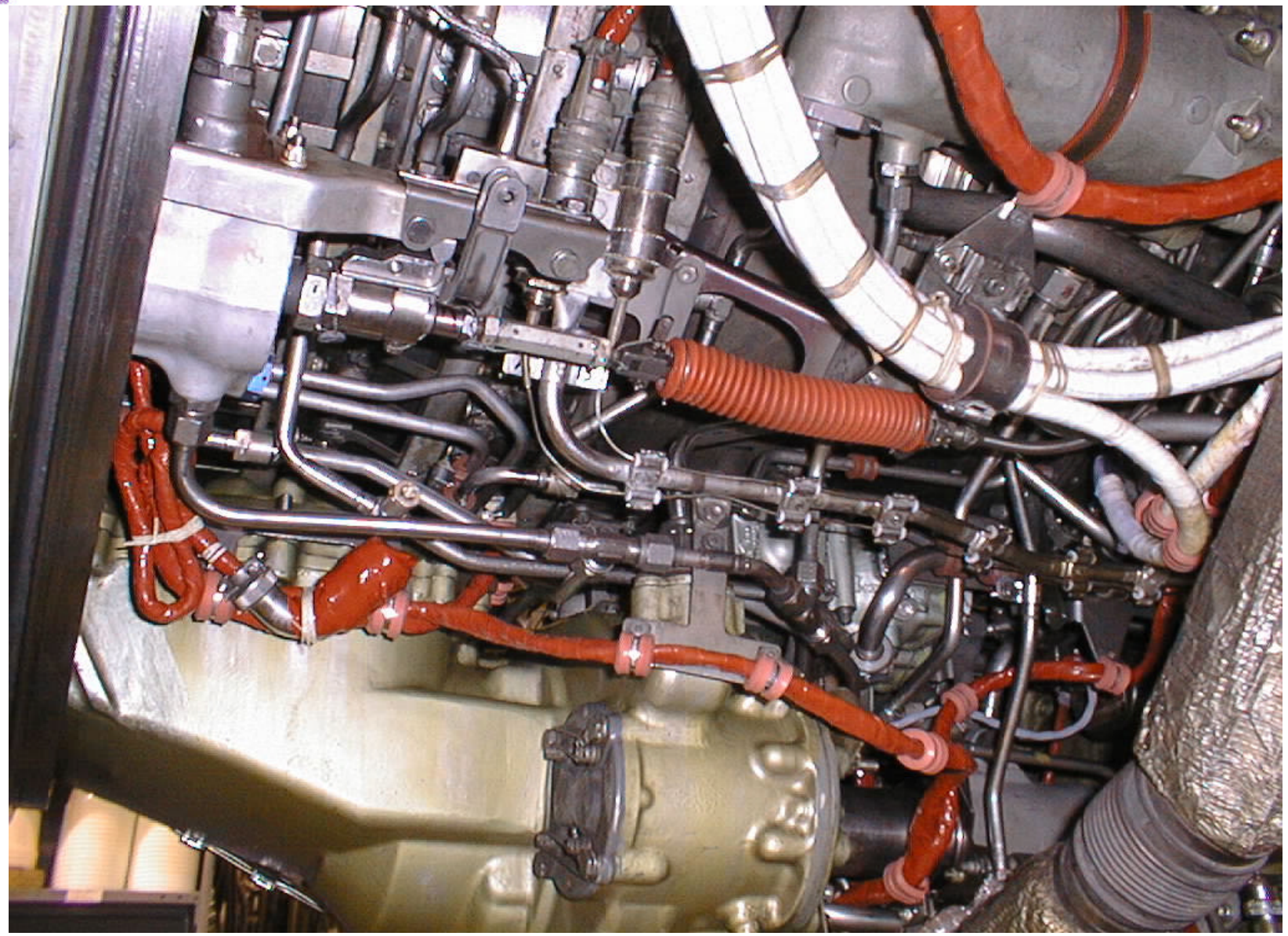
3.0 Bleed Actuator



Compressor Airflow Control System

3.0 BLEED ACTUATOR FEEDBACK CABLE

Purpose:

- The 3.0 bleed actuator feedback cable
  - Supplies 3.0 bleed actuator piston position data to the EVBC.
  - Closes EVBC request / response loop.

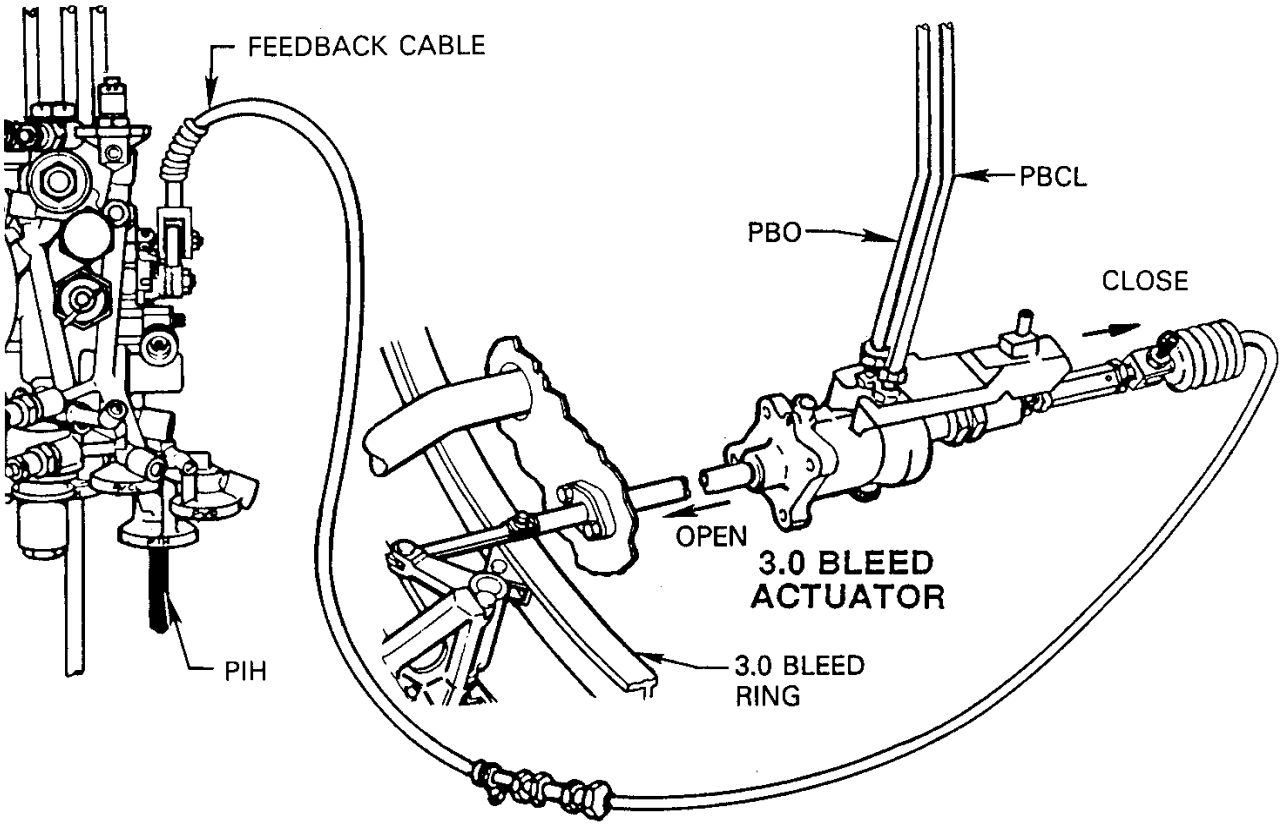
Location:

- The 3.0 bleed actuator feedback cable is attached to the 3.0 bleed valve actuator and EVBC feedback arm.

Description and Operation:

- Two-piece cable assembly (upper and lower)
- Cable assembly transfers linear motion from the 3.0 bleed actuator to the EVBC.
- Cable length adjustable for rigging.

3.0 Modulating Bleed Feedback Cable



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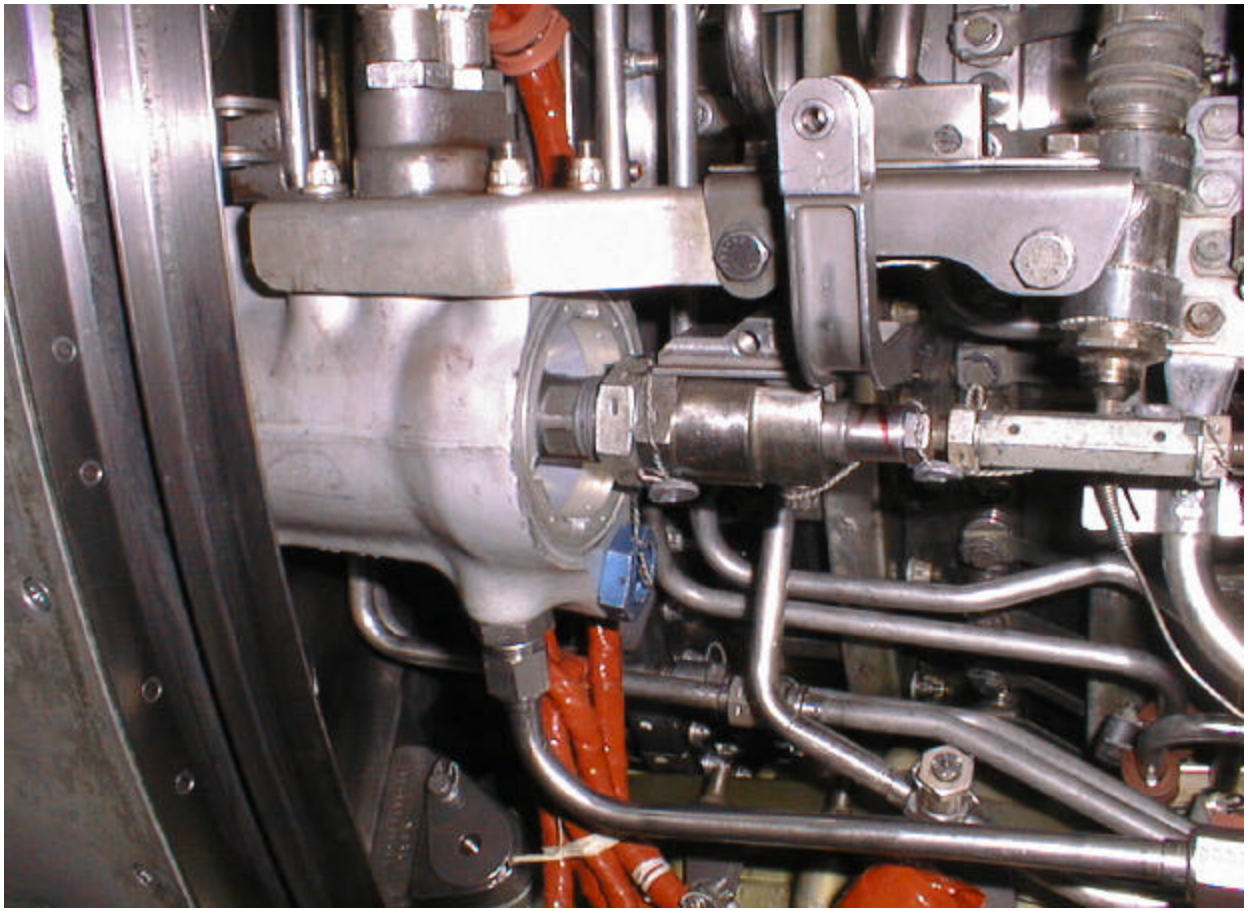
3.0 Bleed Valve Actuator and Feedback Cable



Reverser Actuated Bleed System

GENERAL

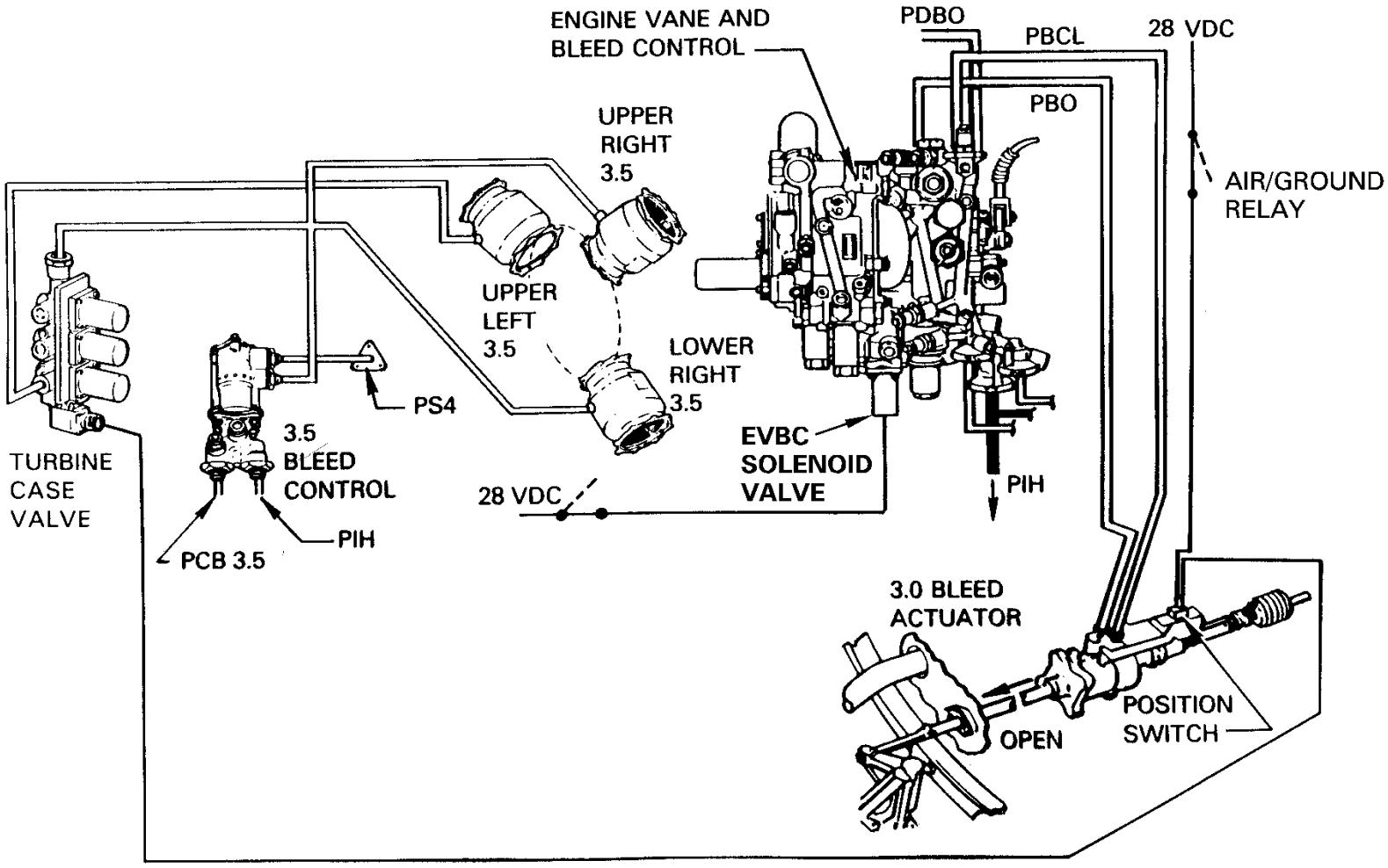
Purpose:

- The Reverser Actuated Bleed System (RABS) ensures compressor stability during reverse thrust operation by bleeding the 4th and 9th stages.

Components:

- EVBC
  - Controls modulating 3.0 bleed actuator and 3.0 bleed ring position
- 3.0 bleed actuator
  - Hydromechanically positions the 3.0 bleed ring
- 3.0 bleed ring
  - Uncovers or covers bleed slots in the fan exit case
  - Full open during reverse thrust operation
- 3.0 bleed actuator feedback cable
  - Provides 3.0 bleed actuator position data to the EVBC
- Upper left hand 3.5 bleed valve
  - Open during reverse thrust operation
  - Bleeds 9th stage air
- 3.5 bleed control valve
  - Controls the flow of Ps4 to the turbine case valve and upper and lower right hand 3.5 bleed valves
- Turbine case solenoid valve
  - Lower solenoid energized by the 3.0 bleed position switch
  - Vents Ps4 from ULH 3.5 bleed valve causing it to open
- EVBC solenoid valve
  - Electromechanically configures EVBC for reverse thrust bleed configuration
  - Energized in reverse thrust operation
  - 28 VDC from the thrust reverser system
  - 3.0 bleed ring is prevented from closing during acceleration in reverse thrust

Reverser Actuated Bleed System



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CT4340

Variable Stator Vane Subsystem

GENERAL

Purpose:

- The variable stator vane subsystem optimizes compressor performance while providing design surge margin.

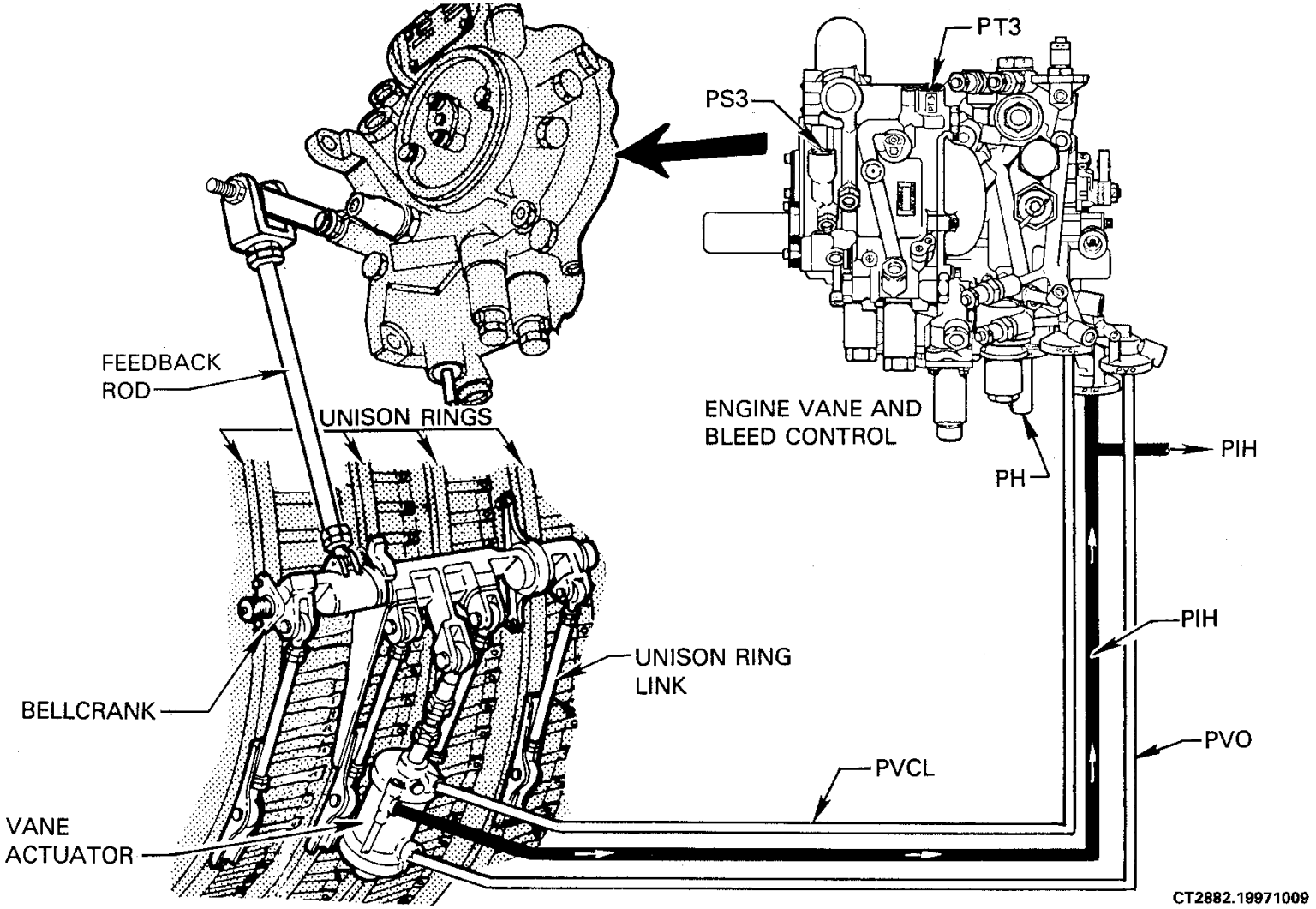
Components:

- PT3 / PS3 input to EVBC from Mach probes
- Engine vane and bleed control
- Vane actuator
- Bellcrank
- Unison ring links
- Unison rings
- Feedback rod

Description and Operation:

- Vane angle is controlled by EVBC
- Scheduled position is based on PT3 and PS3 senses
- N2 IGV and 5th, 6th, and 7th stage stators are variable
- Vanes in each stage are linked by a unison ring
- Unison ring links connect unison rings to bellcrank
- Bellcrank is positioned by the hydraulic actuator
- Vane open and close signals from the EVBC hydraulically position the actuator
  - PVCL: vanes close pressure
  - PVO: vanes open pressure

Variable Stator Vane Subsystem



CT2882

Variable Stator Vane Subsystem - Components

ENGINE VANE AND BLEED CONTROL (EVBC)

Purpose:

- The EVBC is used to control the variable vanes actuator and vane position.

Location:

- The EVBC is found on the HPC at the 3:00 position.

Description and Operation:

- Inputs
  - Pneumatic
    - PT3 and PS3
  - Hydraulic
    - PH - servo and muscle pressure
  - Mechanical
    - Variable vanes bellcrank feedback rod
- Outputs
  - Hydraulic
    - PVO - vanes open pressure
    - PVCL - vanes close pressure
    - PIH - interstage hydraulic pressure

VARIABLE VANE BELLCRANK FEEDBACK ROD

Purpose:

- The variable vane bellcrank feedback rod:
  - Supplies bellcrank angular position to the EVBC.
  - Closes the EVBC request / response loop

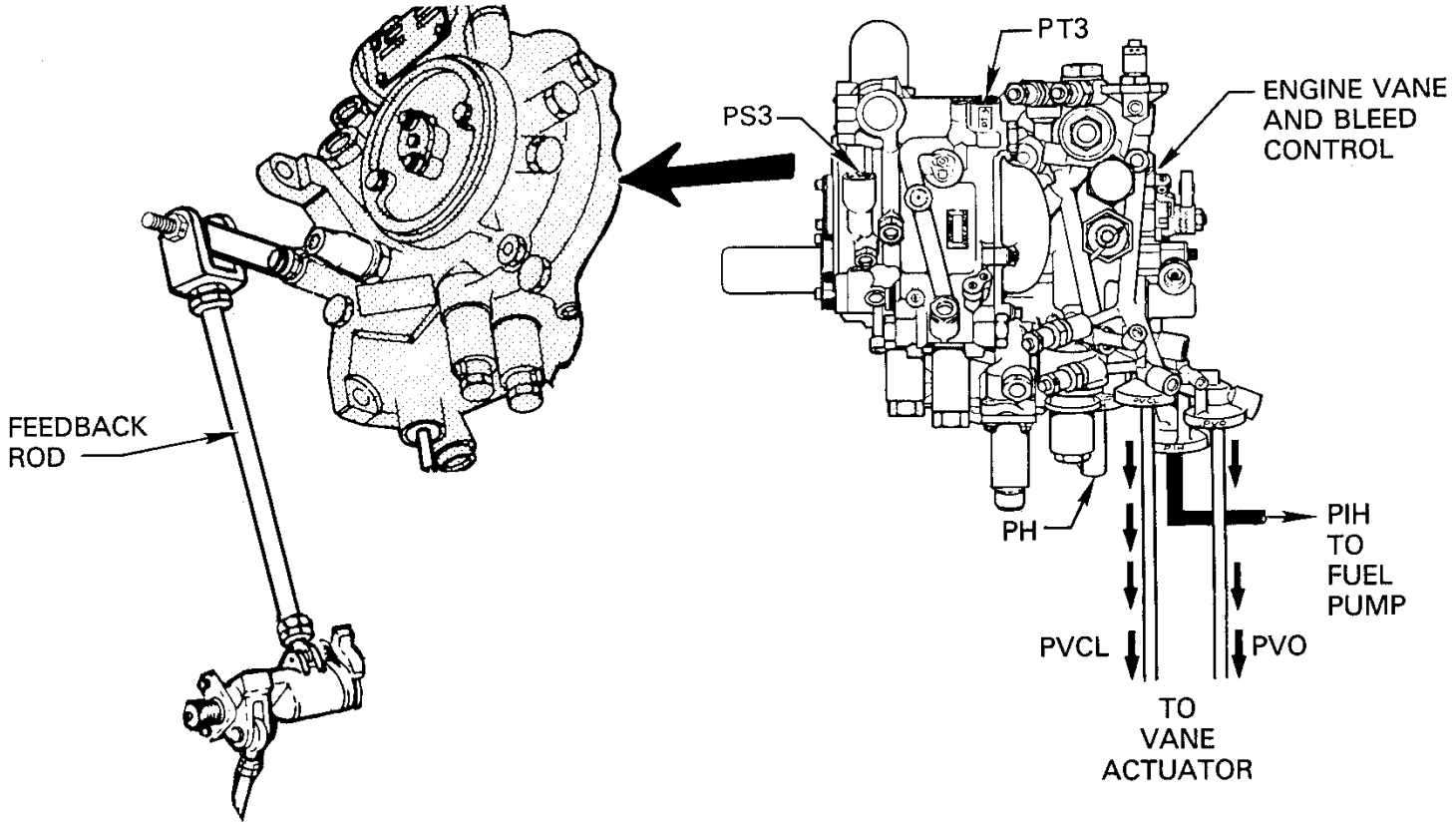
Location:

- The variable vane bellcrank feedback rod interconnects the EVBC and the bellcrank.

Description and Operation:

- Translates bellcrank and vane movement to the EVBC

EVBC/Feedback Rod



CT4102.19971009

CT4102

Variable Stator Vane Subsystem - Components

VANE ACTUATOR

Purpose:

- The vane actuator is used to rotate the bellcrank to position the variable vanes in response to an open or close signal (hydraulic fuel pressure) from the EVBC.

Location:

- The vane actuator is found on the HPC case at the 5:00 position.

Description and Operation:

- Double-acting hydraulic actuator
- Receives PVCL (closed) and PVO (open) pressure from the EVBC
- Also has fuel return port (PIH) for internal leakage and cooling flow return to fuel pump interstage
- Actuator rod is adjustable for rigging of bellcrank throw

BELLCRANK

Purpose:

- The bellcrank is used to transmit actuator rod movement to unison rings and EVBC feedback rod.

Location:

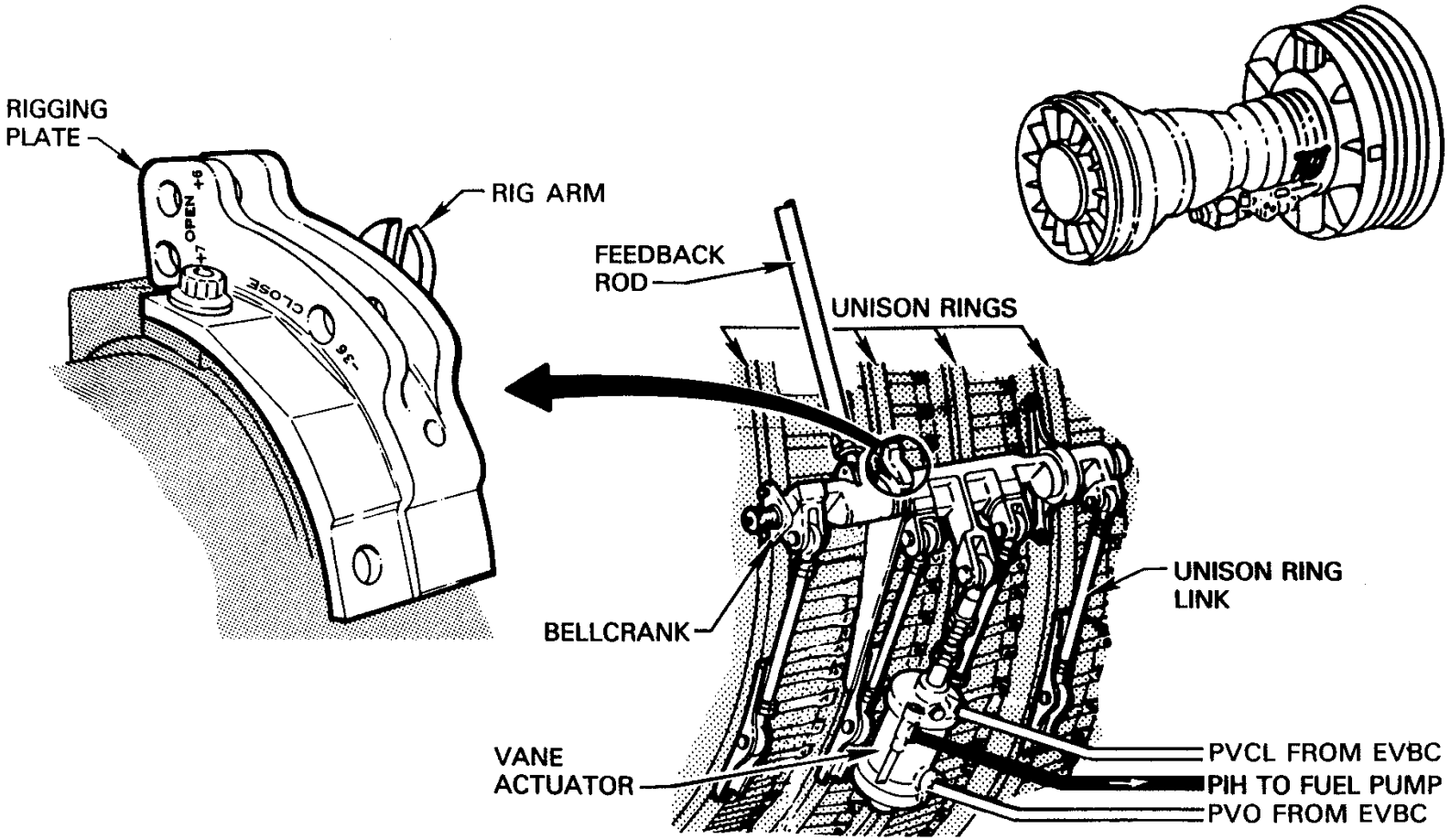
- The bellcrank is found on the HPC case at the 4:30 position.

Description and Operation:

- Rotates through an arc of approximately _____ ^{o}.
- Has provisions for attachment of actuator rod end, unison ring links (4), EVBC feedback rod, and bellcrank angle resolver.

FOR RIGGING AND CHECKING THE STATOR VANES AND ACTUATOR REFER TO THE A310 AMM 75-31-00 AND 75-31-03

Bellcrank/Actuator/Unison Rings



CT4342.19971009

CT4342

Variable Stator Vane Subsystem - Components

UNISON RINGS

Purpose:

- Unison rings convert linear motion to torque in order to position the stator vane arms.

Location:

- Unison rings encircle the HPC at the IGV, 5th, 6th, and 7th stage stator area.

Description and Operation:

- Translate in response to position inputs from the actuator and bellcrank
- Attached to stator vanes by individual stator vane arms

UNISON RING LINKS

Purpose:

- Unison ring links transmit bellcrank movement to the unison rings.

Location:

- Unison ring links interconnect throws on the bellcrank to the unison rings.

Description and Operation:

- Adjustable to permit for synchronizing unison ring movement and variable stator positions

RIGGING PLATE

Purpose:

- The rigging plate gives a reference for mechanical rigging of the variable stator actuating system.

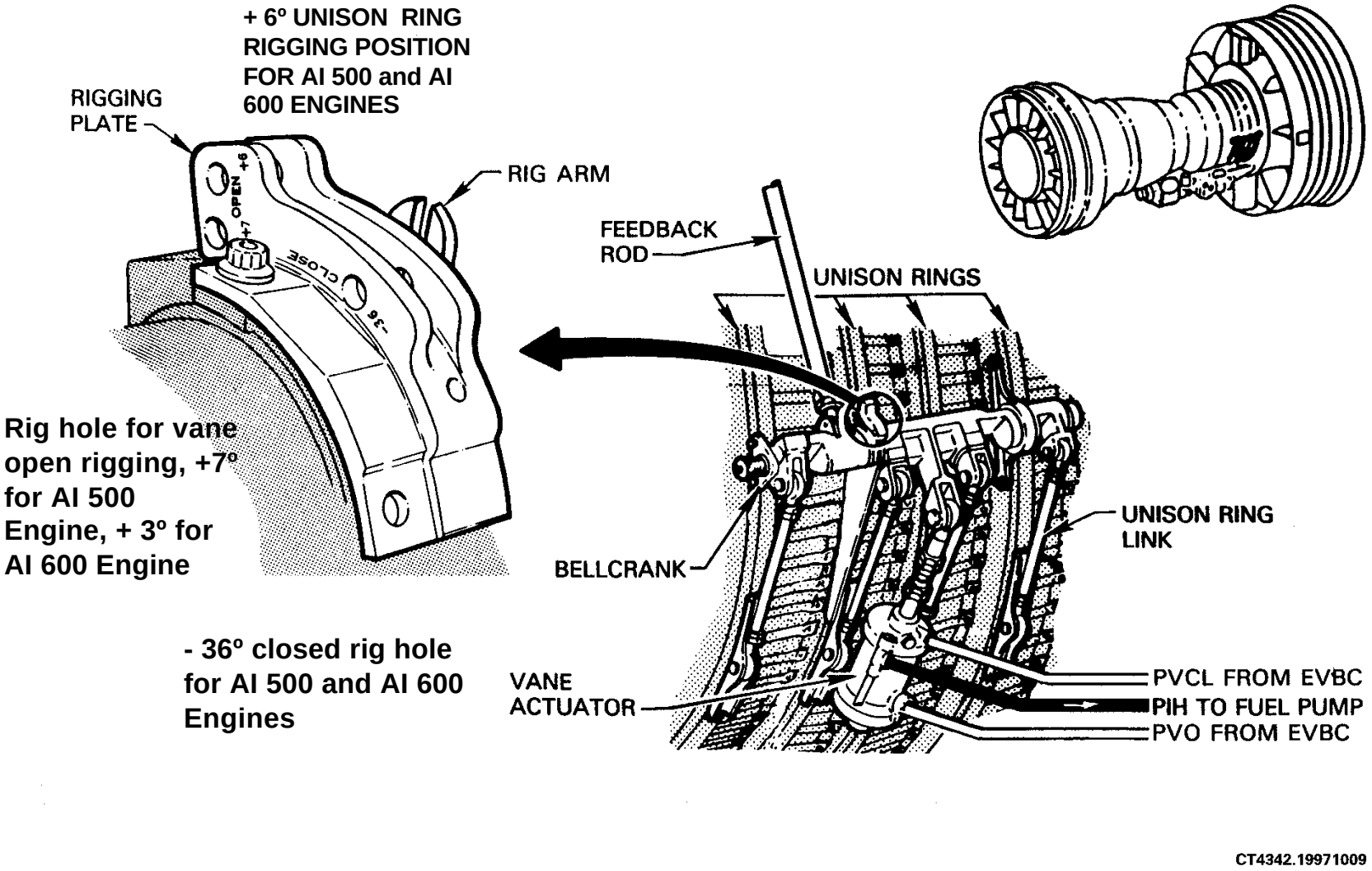
Location:

- The rigging plate is secured to the rear bellcrank bearing journal.

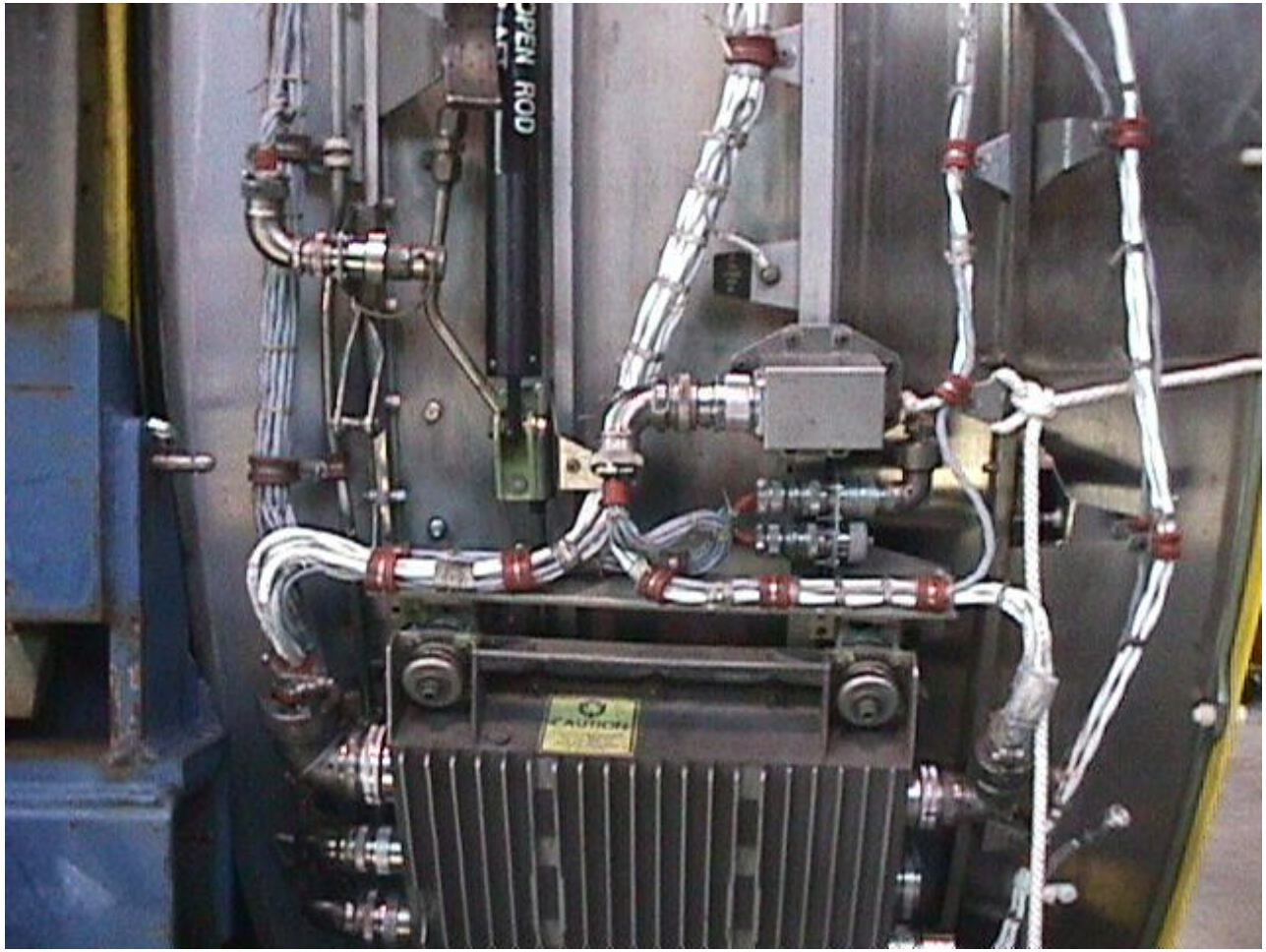
Description and Operation:

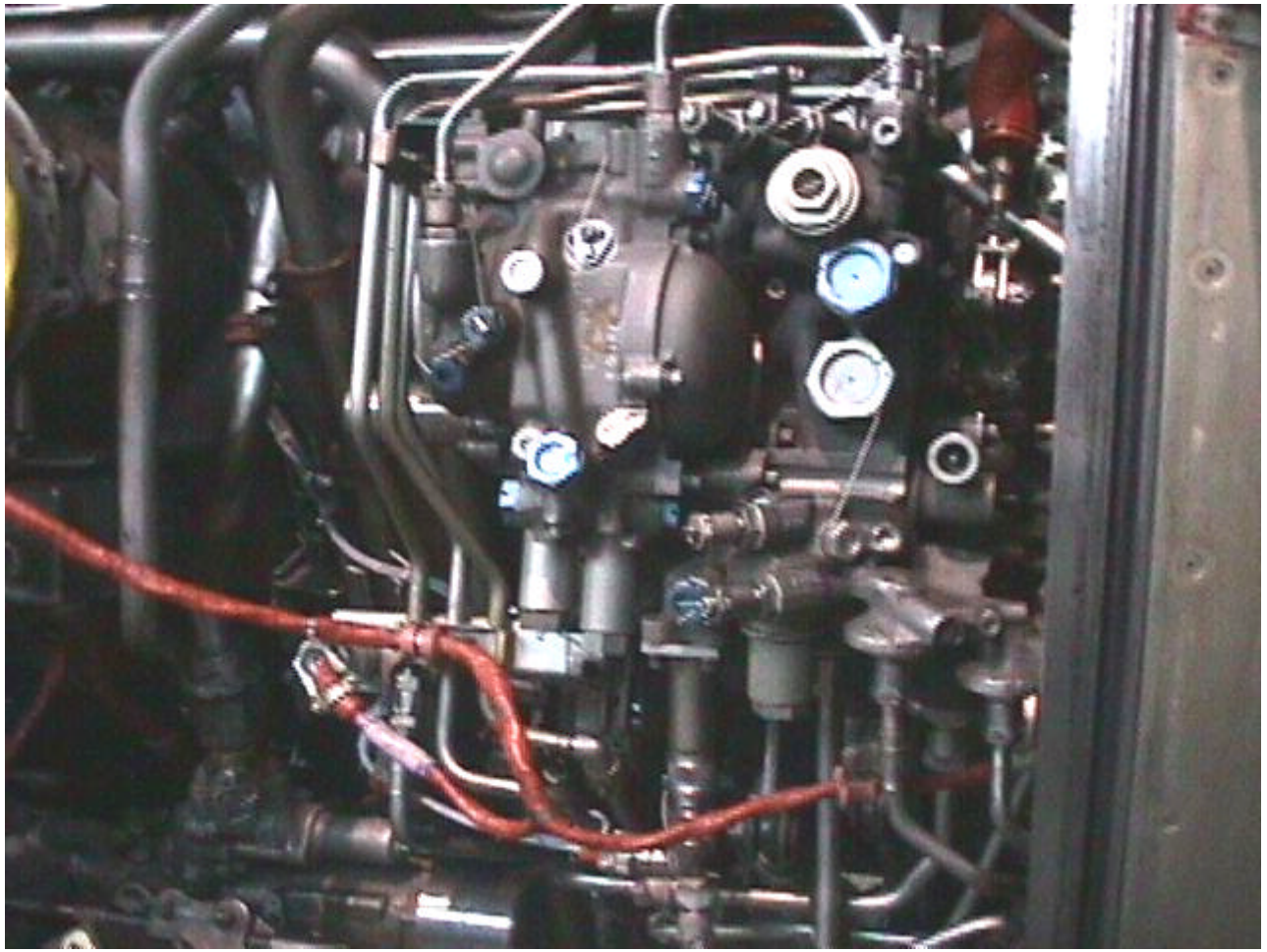
- Has holes for insertion of rig pins to establish vane rigging position and actuator full open and full close vane positions during rigging
  - Full open **+ 7º (AI500) ,+ 3º (AI 600)**
  - Full closed **- 36º (AI 500/AI 600)**
  - Rig **+ 6º UNISON RING (AI 500 and AI 600)**

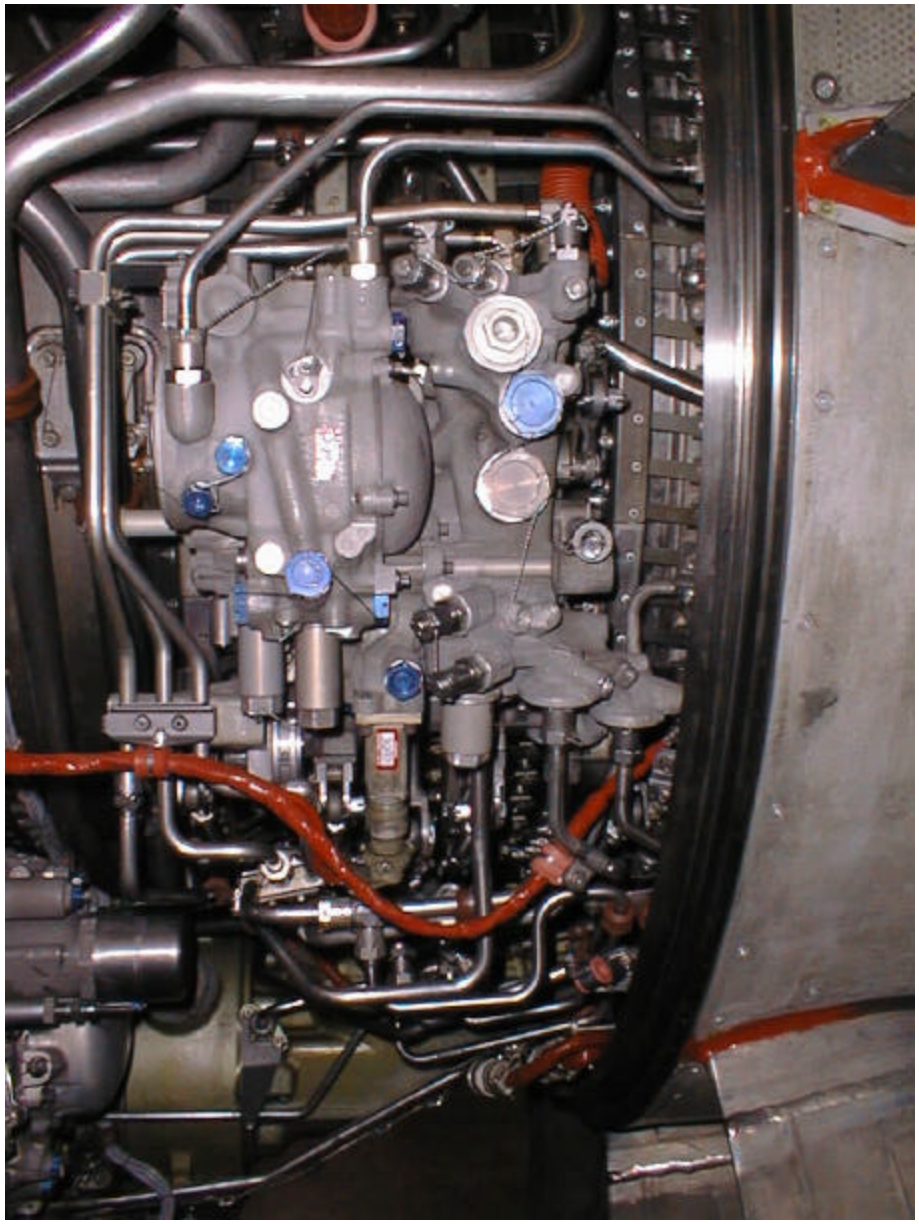
Bellcrank/Actuator/Unison Rings

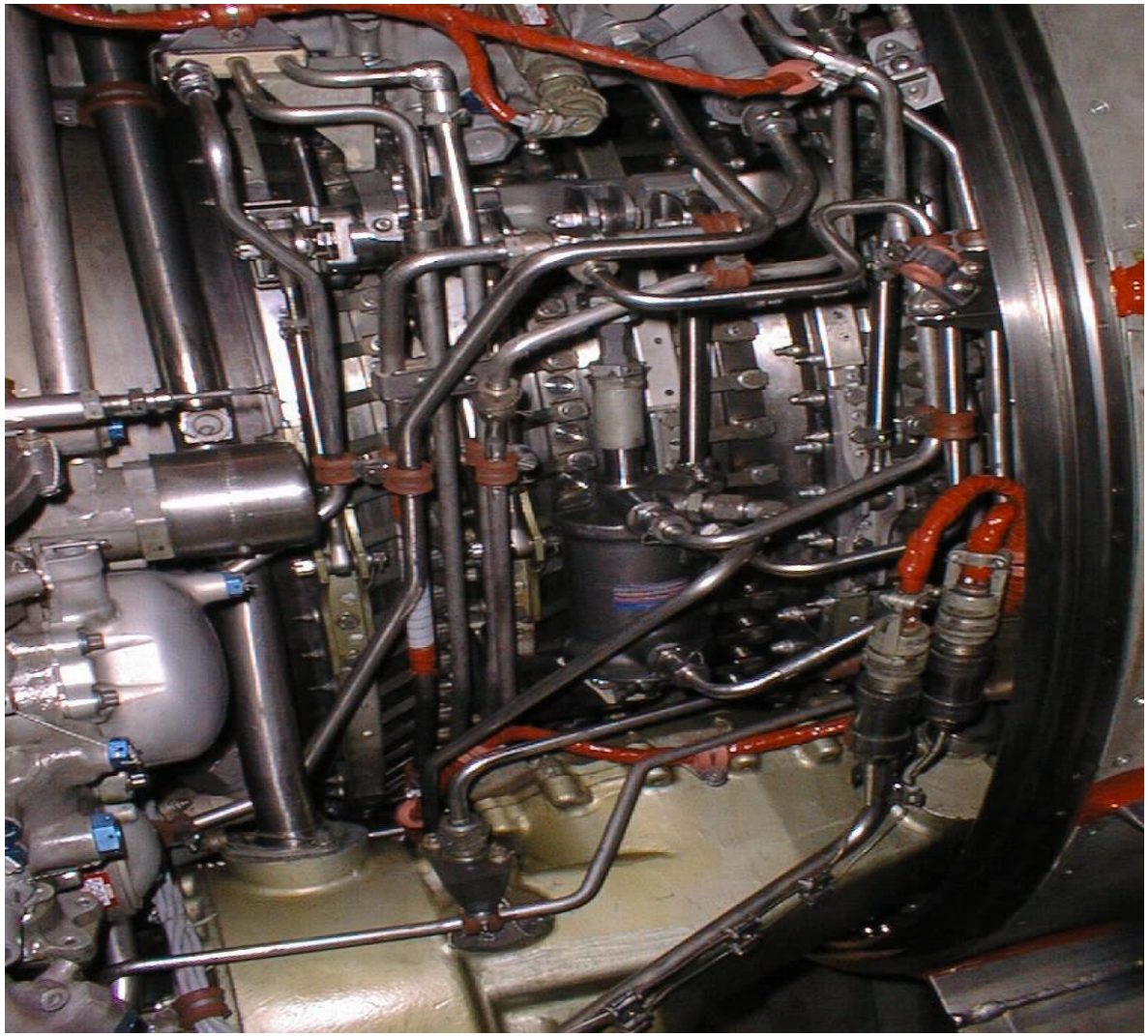

+ 6º UNISON RING RIGGING POSITION FOR AI 500 and AI 600 ENGINES
RIGGING PLATE
RIG ARM
OPEN +6
CLOSE -36
FEEDBACK ROD
UNISON RINGS
Rig hole for vane open rigging, +7º for AI 500 Engine, + 3º for AI 600 Engine
UNISON RING LINK
BELLCRANK
- 36º closed rig hole for AI 500 and AI 600 Engines
VANE ACTUATOR
PVCL FROM EVBC
PIH TO FUEL PUMP
PVO FROM EVBC

CT4342.19971009


OPEN ROD
CAUTION







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AUTOMATIC ROTOR CLEARANCE CONTROL SYSTEM (ARCCS)

Automatic Rotor Clearance Control System

GENERAL

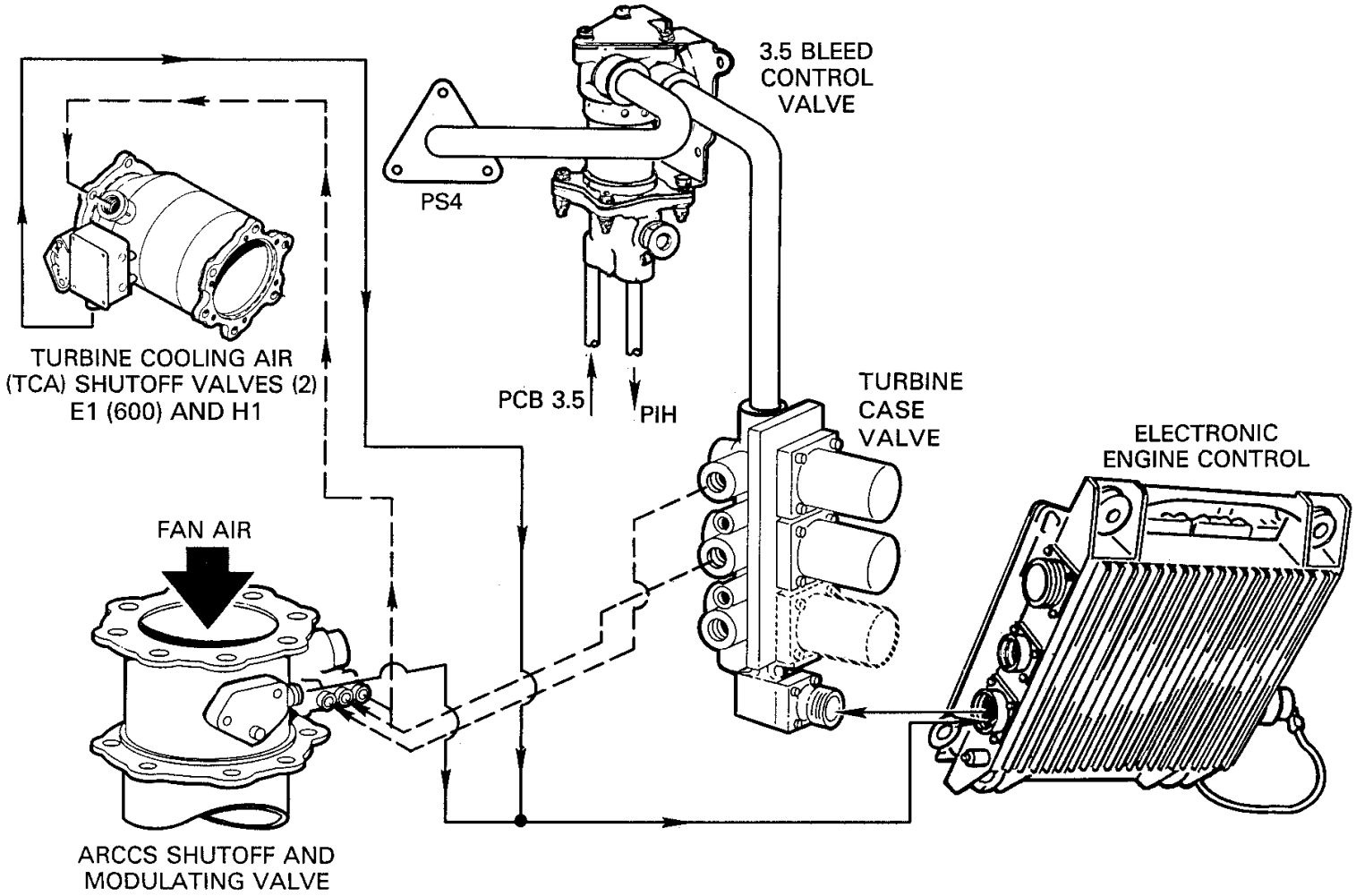
Purpose:

- The Automatic Rotor Clearance Control System (ARCCS) is used to control turbine running tip clearances to optimize performance and lower TSFC.

Components:

- Electronic engine control
- Turbine case valve
- ARCCS shutoff and modulating valve
- Turbine cooling air valves (E1(600) and H1 only)
  - Left side
  - Right side
- 3.5 bleed control valve
- Turbine case cooling manifolds

Automatic Rotor Clearance Control System

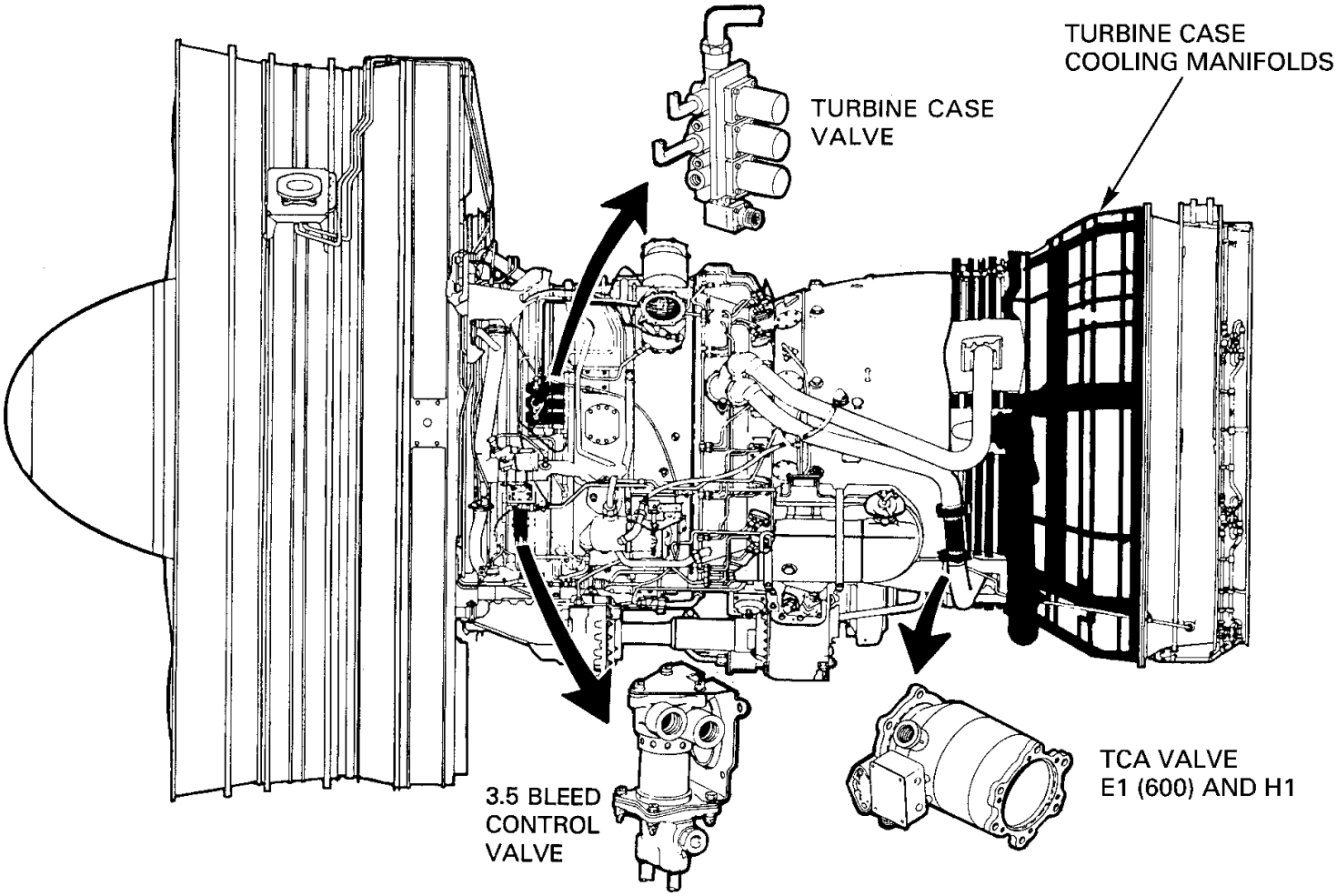


CT4105

ARCCS - Left Side

- Turbine case valve
  - Mounted on the HPC case at the 9:00 position
- Turbine cooling air valve (E1(600) and H1 only)
  - Found in the lower left hand 13th stage turbine cooling air duct
- Turbine case cooling manifolds
  - Encircle the high and low pressure turbine cases
- 3.5 bleed control valve
  - Found on the HPC case at the 8:30 position

ARCCS - Left Side



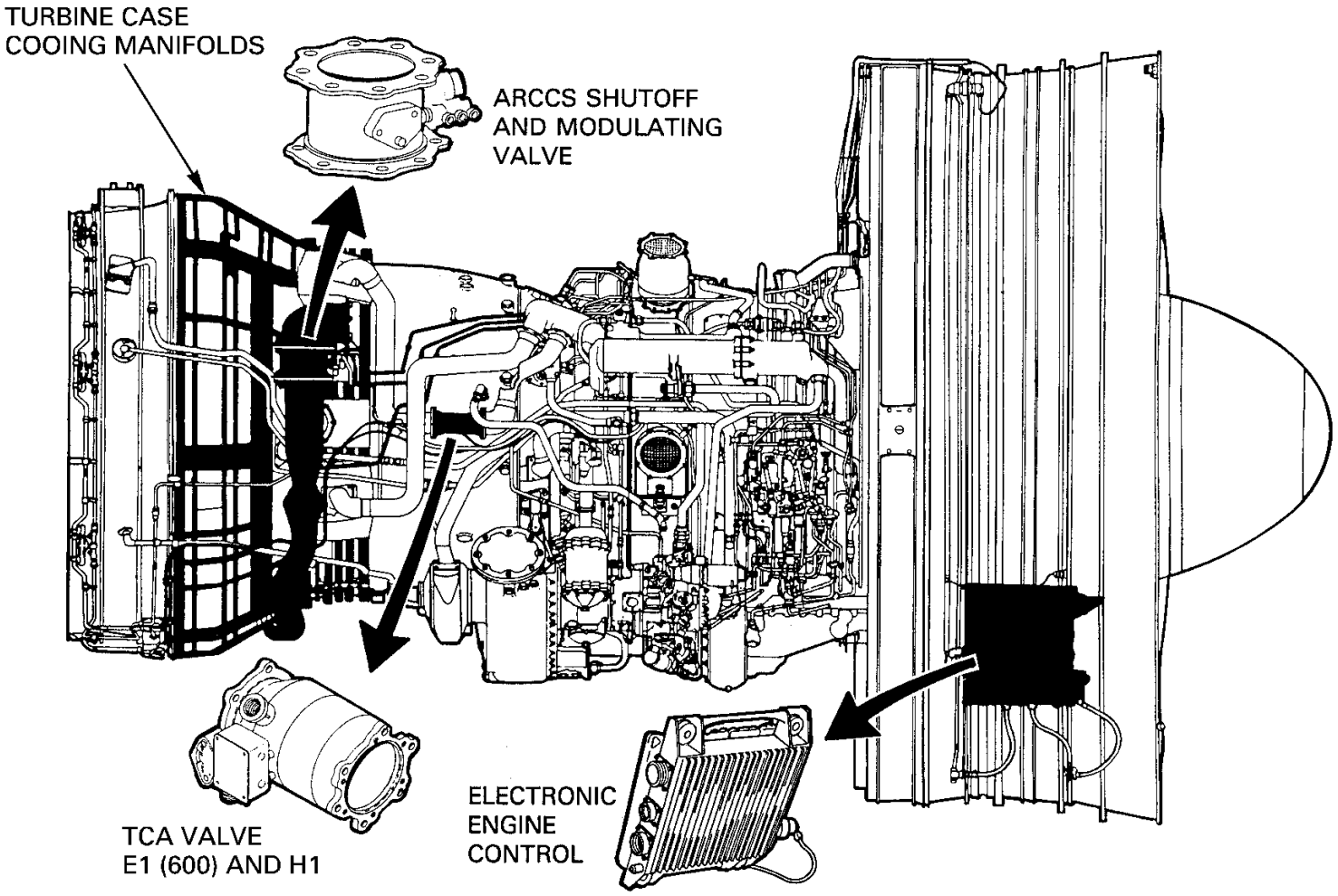
CT4106.19980318

CT4106

ARCCS - Right Side

- Electronic engine control
  - Mounted on the fan exit case at the 5:00 position
- ARCCS shutoff and modulating valve
  - Mounted on the HPT case at the 2:30 position
- Turbine cooling air valve (E1(600) and H1 only)
  - Found in the upper right hand 13th stage turbine cooling air duct
- Turbine case cooling manifolds
  - Encircle the high and low pressure turbine cases

ARCCS - Right Side



CT4107.19980318

CT4107

Electronic Engine Control (EEC) - Components

Purpose:

- The Electronic Engine Control (EEC) controls ARCCS fan airflow for all engine models and turbine cooling airflow for E1(600) and H1 models only

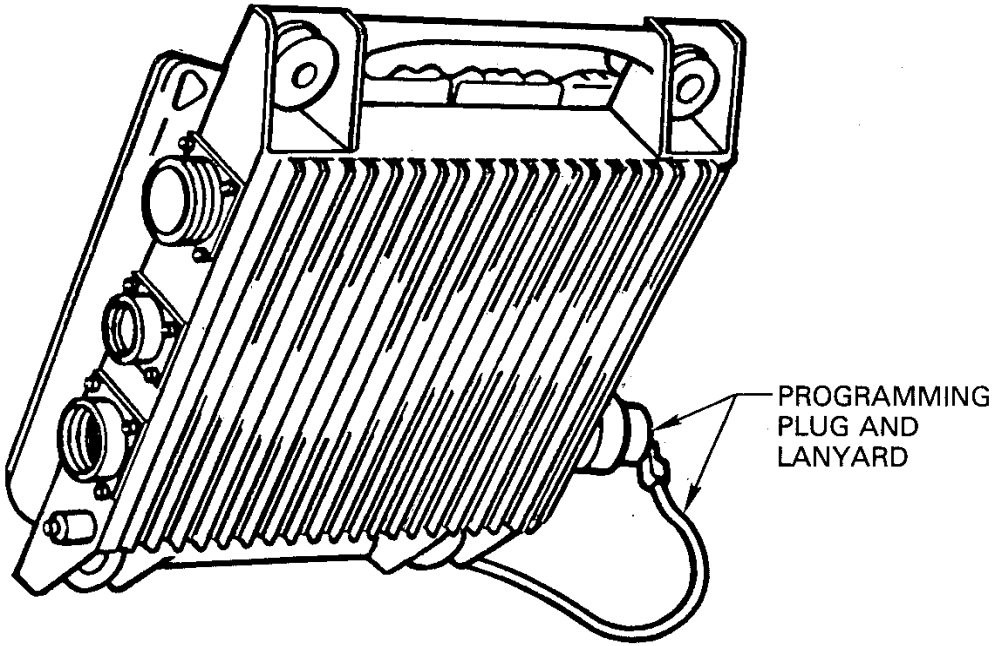
Location:

- The electronic engine control is found on the fan case at the 5:00 position.

Description and Operation:

- Inputs
  - 28VDC from the turbine case valve
  - N2 from the EEC generator
  - Slat position from slat / flap control computer (SFCC)
  - Air / ground logic from ground safety relay switch
  - Altitude - alternate from air data computers
  - ARCCS shutoff and modulating valve position feedback

Electronic Engine Control



CT4110.19971009

CT4110

Turbine Case Valve

Purpose:

- The turbine case valve pneumatically controls the ARCCS shutoff and modulating valve for all models and the turbine cooling air valves for the E1(600) and H1 models only.

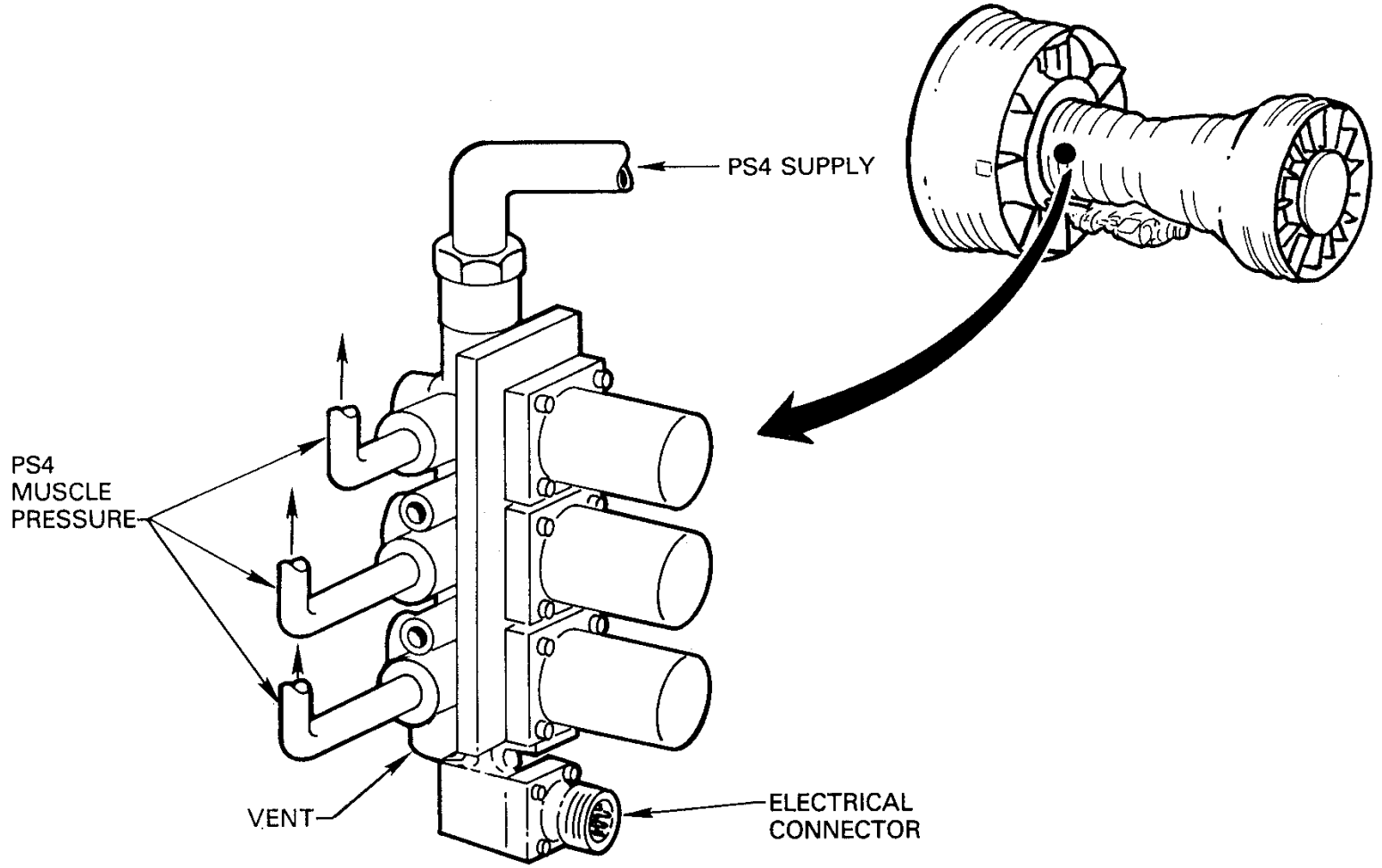
Location:

- The turbine case valve is found on the high pressure compressor case at the 9:30 position.

Description and Operation:

- Inputs
  - 28VDC from the aircraft supply
  - PS4 from the 3.5 bleed control valve
- Output
  - PS4 to the ARCCS shutoff and modulating valve
  - PS4 to the turbine cooling air valves (E1(600) and H1 models only)

Turbine Case Valve



CT4376.19971009

CT4376

ARCCS Shutoff and Modulating Valve

Purpose:

- The ARCCS shutoff and modulating valve controls the fan airflow to the turbine case cooling manifolds.

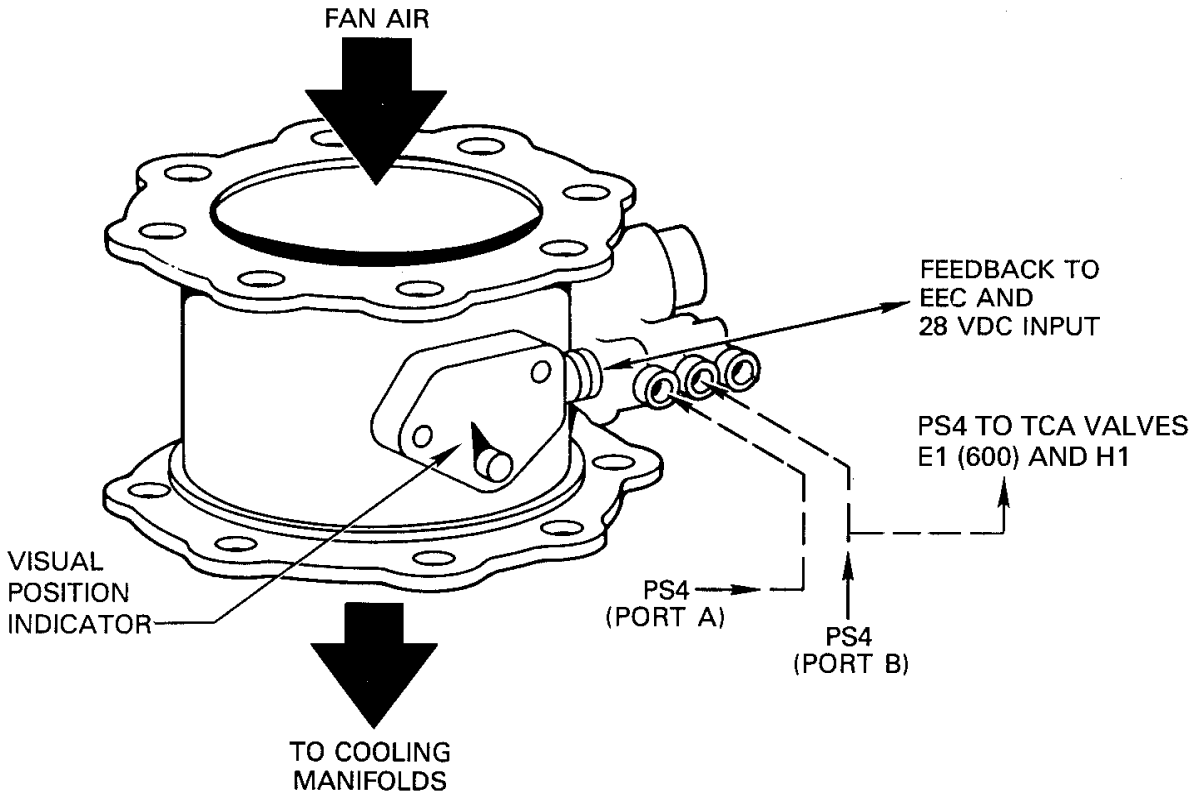
Location:

- The ARCCS shutoff and modulating valve is found on the high pressure turbine case at the 2:30 position.

Description and Operation:

- Four-position butterfly valve
  - Off
  - Minimum flow
  - Intermediate flow
  - Maximum flow
- Pneumatically controlled
- PS4 ports
  - Port A
  - Port B
- Has visual position indicator
- Inputs
  - Fan air
  - PS4 from the turbine case valve
    - Port A
    - Port B
  - 28VDC from the aircraft electrical system DC bus
- Outputs
  - Fan air to turbine case cooling manifolds
  - Position feedback to EEC

ARCCS Shutoff and Modulating Valve



CT4111.19980318

CT4111

3.5 Bleed Control Valve

Purpose:

- The 3.5 bleed control valve controls the flow of PS4 to the 3.5 bleed valves and turbine case valve.

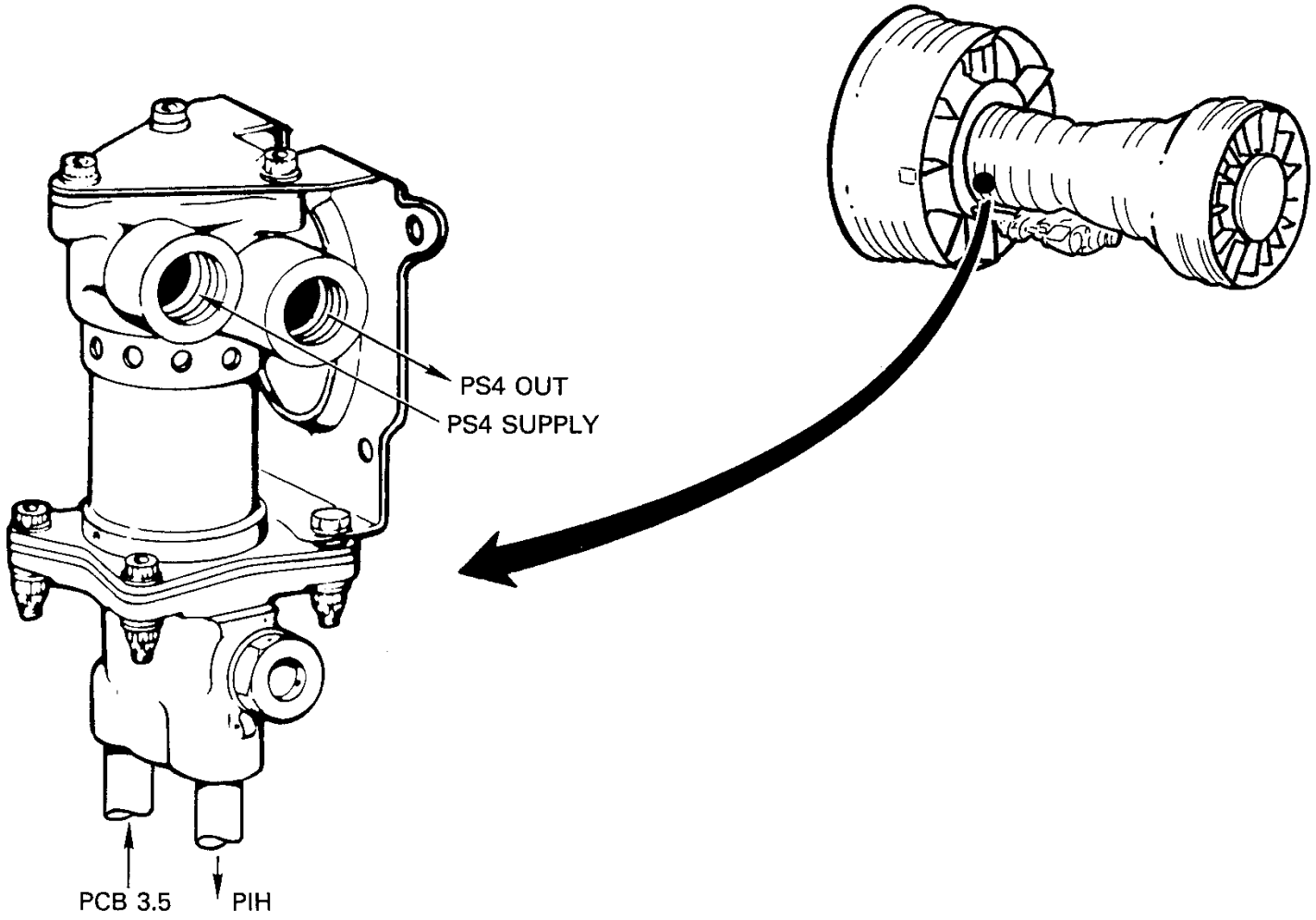
Location:

- The 3.5 bleed control valve is mounted on the HPC case at the 8:30 position.

Description and Operation:

- Inputs
  - PS4 from the engine diffuser case at the 10:30 position
  - PCB3.5 from the hydromechanical fuel control (50% N2)
- Outputs
  - PS4 to the 3.5 bleed valves
  - PS4 to the turbine case valve
  - PIH to the engine-driven fuel pump interstage

3.5 Bleed Control Valve



CT4093.19971009

CT4093

Turbine Cooling Air Valves (E1(600) and H1)

Purpose:

- The turbine cooling air valves (E1(600) and H1) control 13th stage air for high pressure turbine internal cooling.

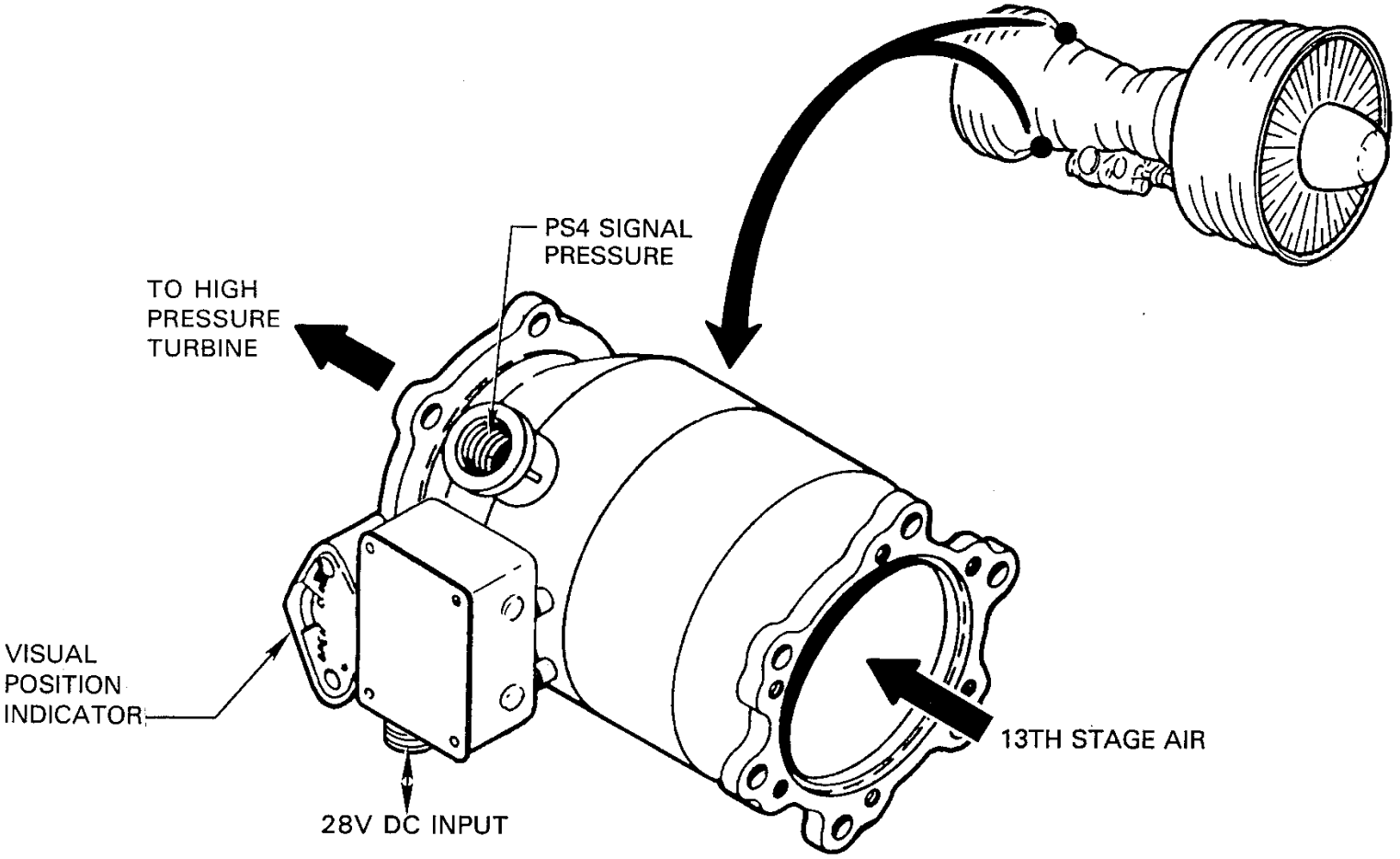
Location:

- The turbine cooling air valves (E1(600) and H1) are found in the URH and LLH 13th stage cooling ducts.

Description and Operation:

- Two-position valve
  - Open
  - Closed
- Pneumatically controlled by PS4
- Has visual position indicator
- Inputs
  - PS4 from turbine case valve
  - 28VDC from aircraft electrical system DC bus
- Outputs
  - 13th stage air to high pressure turbine
  - Position feedback to EEC

Turbine Cooling Air Valves (E1(600) and H1)



CT4112.19971009

CT4112

ARCCS Indication

TURBINE CASE COOL LIGHT (ALL MODELS)

Purpose:

- The turbine case cool light supplies ARCCS shutoff and modulating valve position information for disagreement and fault logic.

Location:

- The turbine case cool light is found on the lower center panel on the flight deck.

Description and Operation:

- Normally extinguished
- Illuminates amber
  - Disagreement
  - Fault

CASE COOL LIGHTS (ALL MODELS)

Purpose:

- The case cool light supplies ARCCS shutoff and modulating valve position information for disagreement and fault logic.

Location:

- The case cool light is found on the maintenance panel on the flight deck

Description and Operation:

- Normally extinguished
- Illuminates amber
  - Disagreement
  - Fault

TURBINE COOL LIGHTS (E1(600) AND H1)

Purpose:

- The turbine cool lights supply TCA valve position information for disagreement and fault logic.

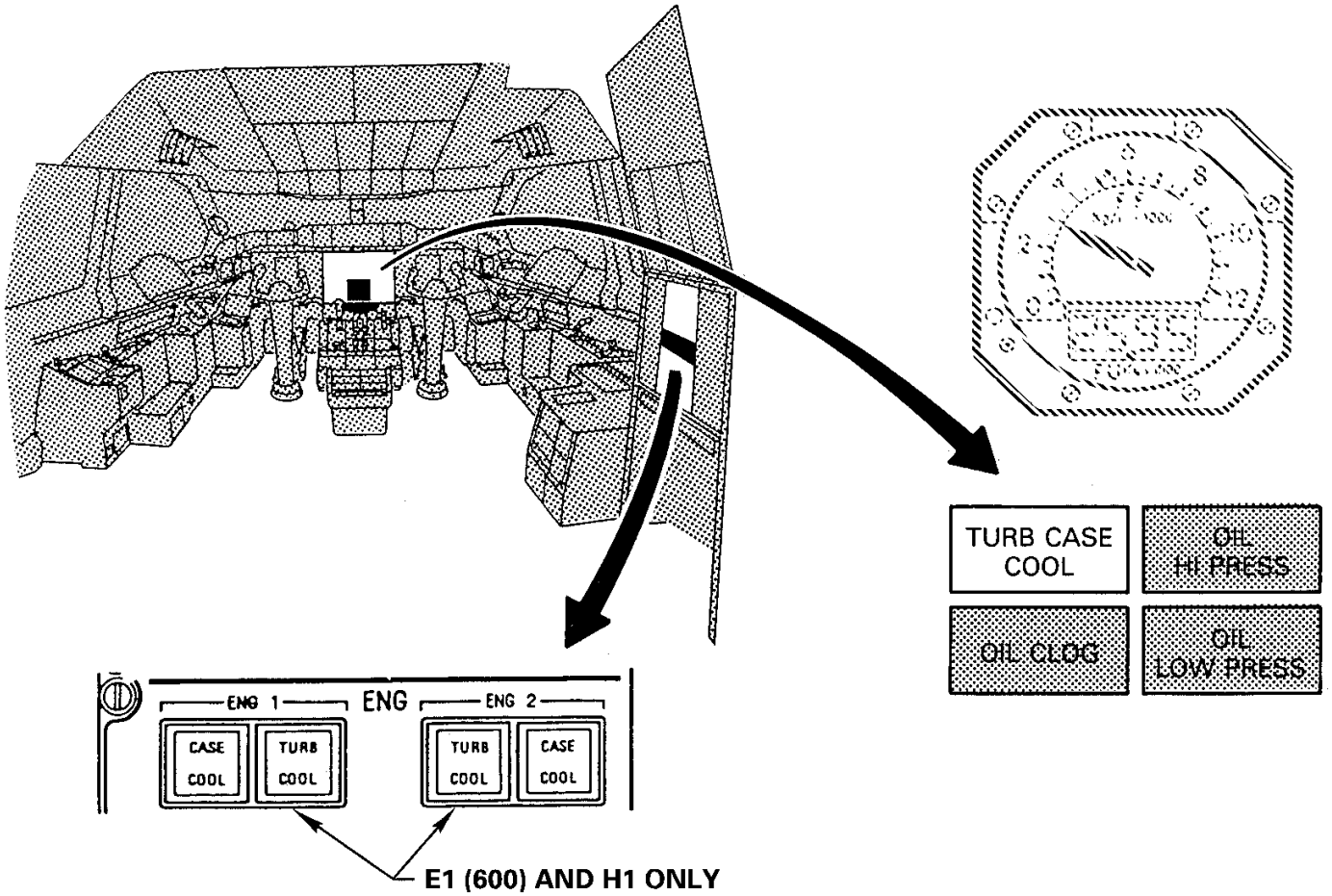
Location:

- The turbine cool lights are found on the maintenance panel on the flight deck.

Description and Operation:

- Normally extinguished
- Illuminates amber
  - Disagreement
  - Fault

ARCCS Indication



CT4113.19980318

CT4113

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OIL SYSTEM

OVERALL SYSTEM DATA

GENERAL

Purpose:

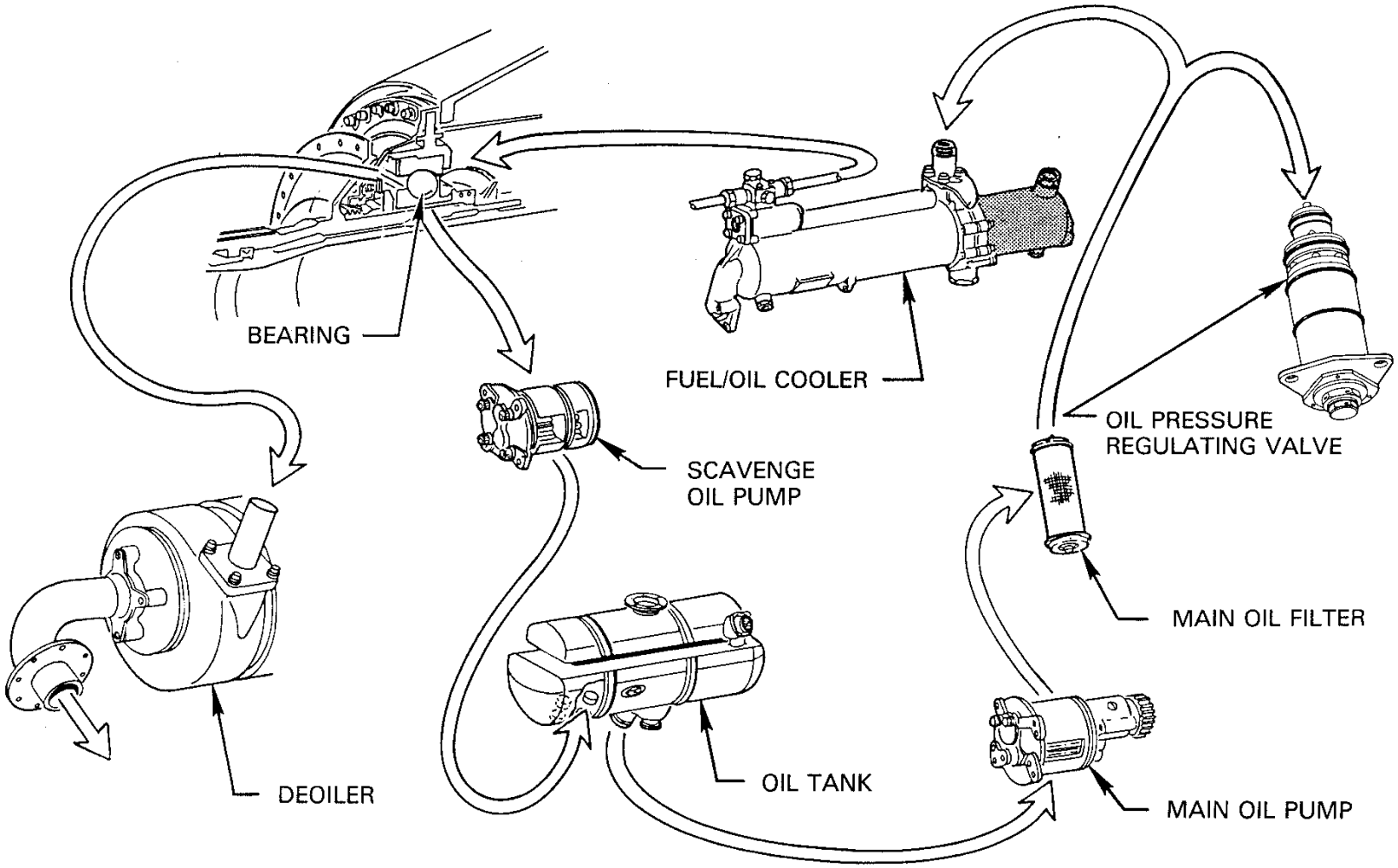
- The oil system is a self-contained, hot tank system which supplies pressurized oil for lubricating, cooling, and cleaning main bearings, gearbox gear trains and accessory drives..

Components:

- Oil tank
- Main oil pump
- Main oil filter
- Oil pressure regulating valve
- Fuel / oil cooler
- Scavenge pumps
- Deoiler

- **Flow sequence**
  - Tank to main oil pump
  - Main oil pump to main oil filter
  - Main oil filter to pressure regulating valve and fuel / oil cooler
  - Fuel / oil cooler to last chance filters and oil nozzles
  - Scavenge oil is picked up by the scavenge pumps and returned to the oil tank
  - Breather air is routed to the deoiler where the oil is removed for scavenging and the dry air is vented overboard
- **System limits**
  - Pressure
    - Minimum: 40 psi
    - Maximum: 60 psi
  - Temperature
    - Continuous: 135^{o}C
    - Transient: 163^{o}C
  - Consumption:
    - Qt / hr: 0.5
  - Breather pressure
    - Psi: 2
- **Oil specification**
  - PWA 521
  - PWA Service Bulletin 238
    - Lists approved oil by brand

Oil System

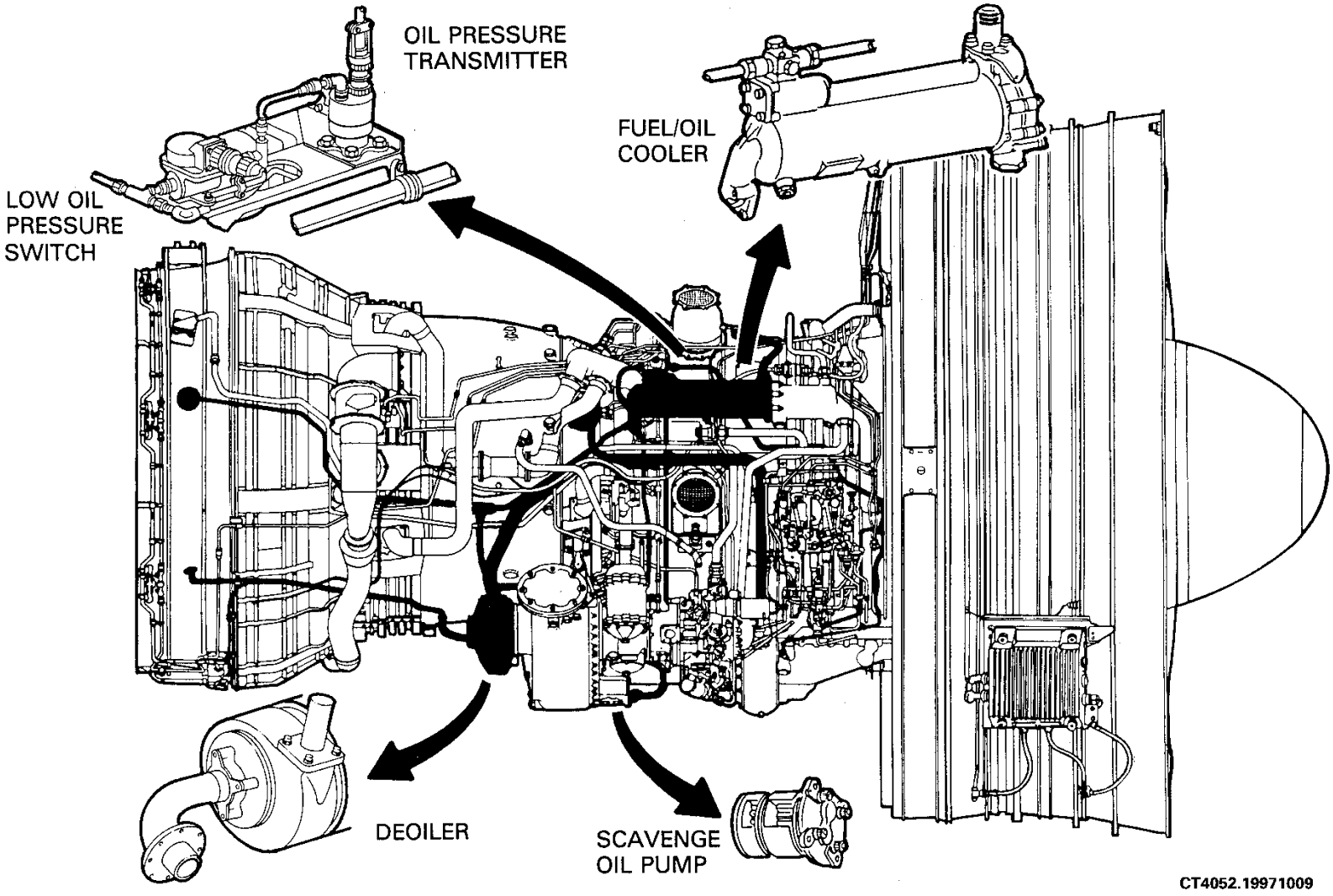


CT4051

Oil System Components - Right Side

- Fuel / oil cooler
  - Mounted on the HPC case at the 2:30 position
- External deoiler
  - Mounted on the right rear face of the main gearbox
- Scavenge pump
  - Mounted on the right front face of the main gearbox
- Oil pressure transmitter and low oil pressure warning switch
  - Mounted on the fuel / oil cooler bracket at the 2:00 position

Oil System Components - Right Side

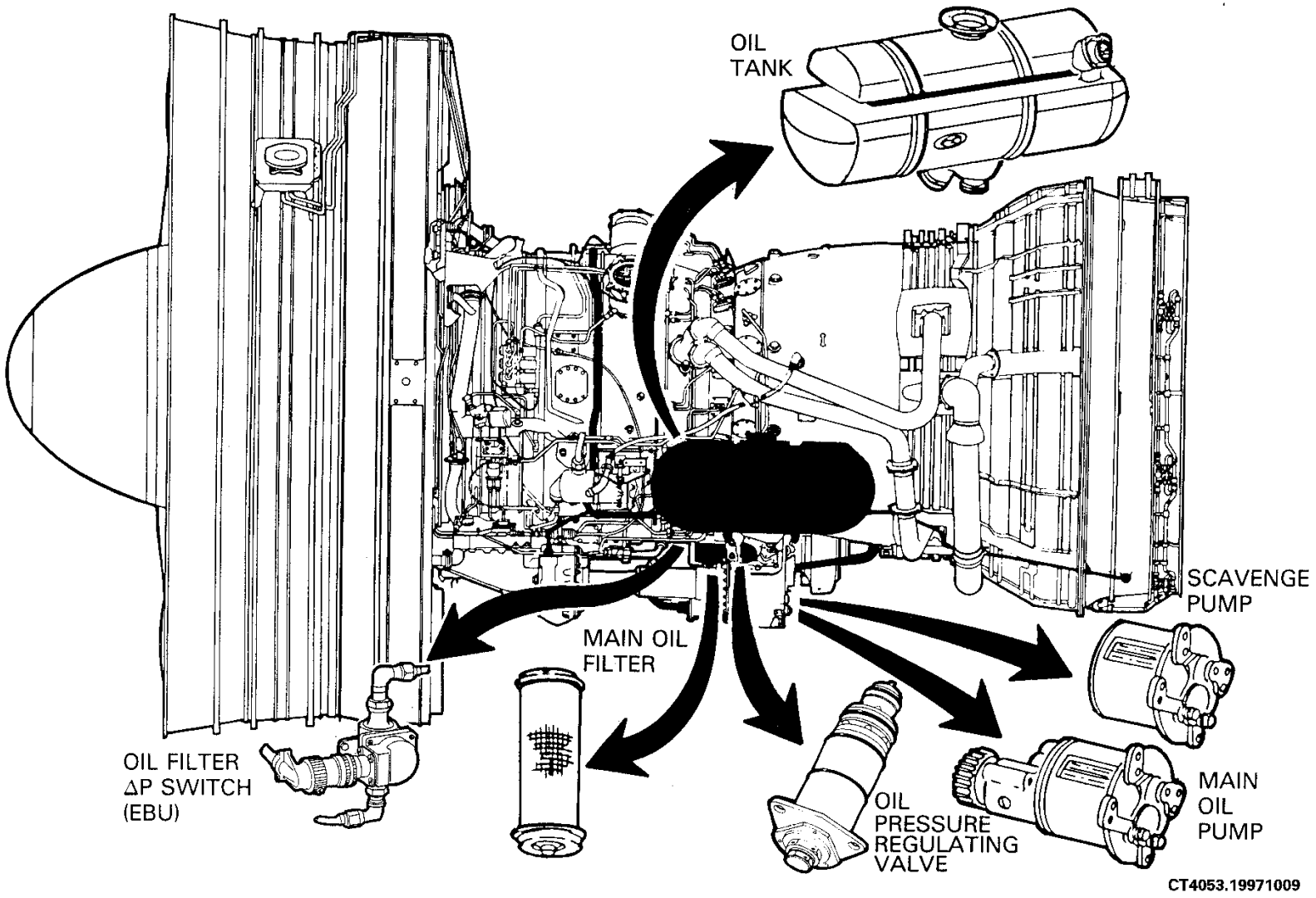


CT4052

Oil System Components - Left Side

- Oil tank
  - Mounted on the left side of the main gearbox
- Oil filter
  - Mounted on the left side of the main gearbox
- Pressure regulating valve
  - Mounted on the left side of the main gearbox
- Pressure pump
  - Mounted on the rear face of the main gearbox
- Scavenge pump
  - Mounted on the rear face of the main gearbox
- Oil filter ΔP switch
  - Mounted forward of the oil filter at the 8:00 position

Oil System Components - Left Side



CT4053

Oil Tank

Purpose:

- The oil tank is the reservoir for the oil supply.

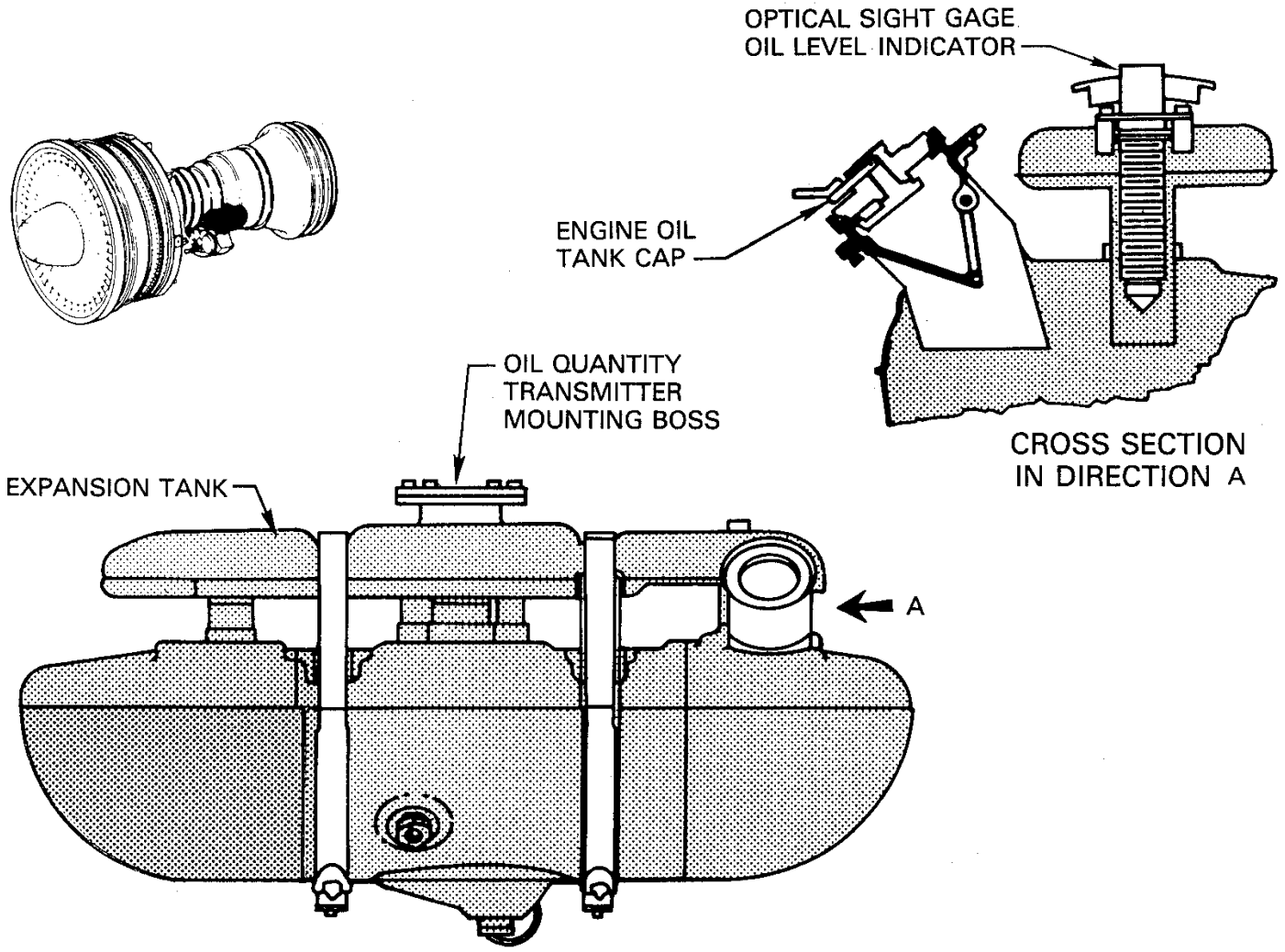
Location:

- The oil tank is found on the left side of the main gearbox.

Description and Operation:

- Stainless steel weldment contoured for equal volume
- Integral flapper valve in filler neck reduces oil loss rate if oil service cap is not correctly secured or missing
- Optical sight gage
  - Reflective return from flashlight beam indicates the oil level is at least one quart low
  - No reflective return indicates that the oil level is satisfactory
- Oil transfer tubes
  - Supply (to main oil pump inlet)
  - Scavenge (oil return to tank)
  - Vent (orifice check valve maintains correct tank pressure of 4-6 psig)

Oil Tank



CT4055.19971009

CT4055

Oil Pump

Purpose:

- The oil pump supplies pressurized oil at the correct flow rate to meet lubrication requirements.

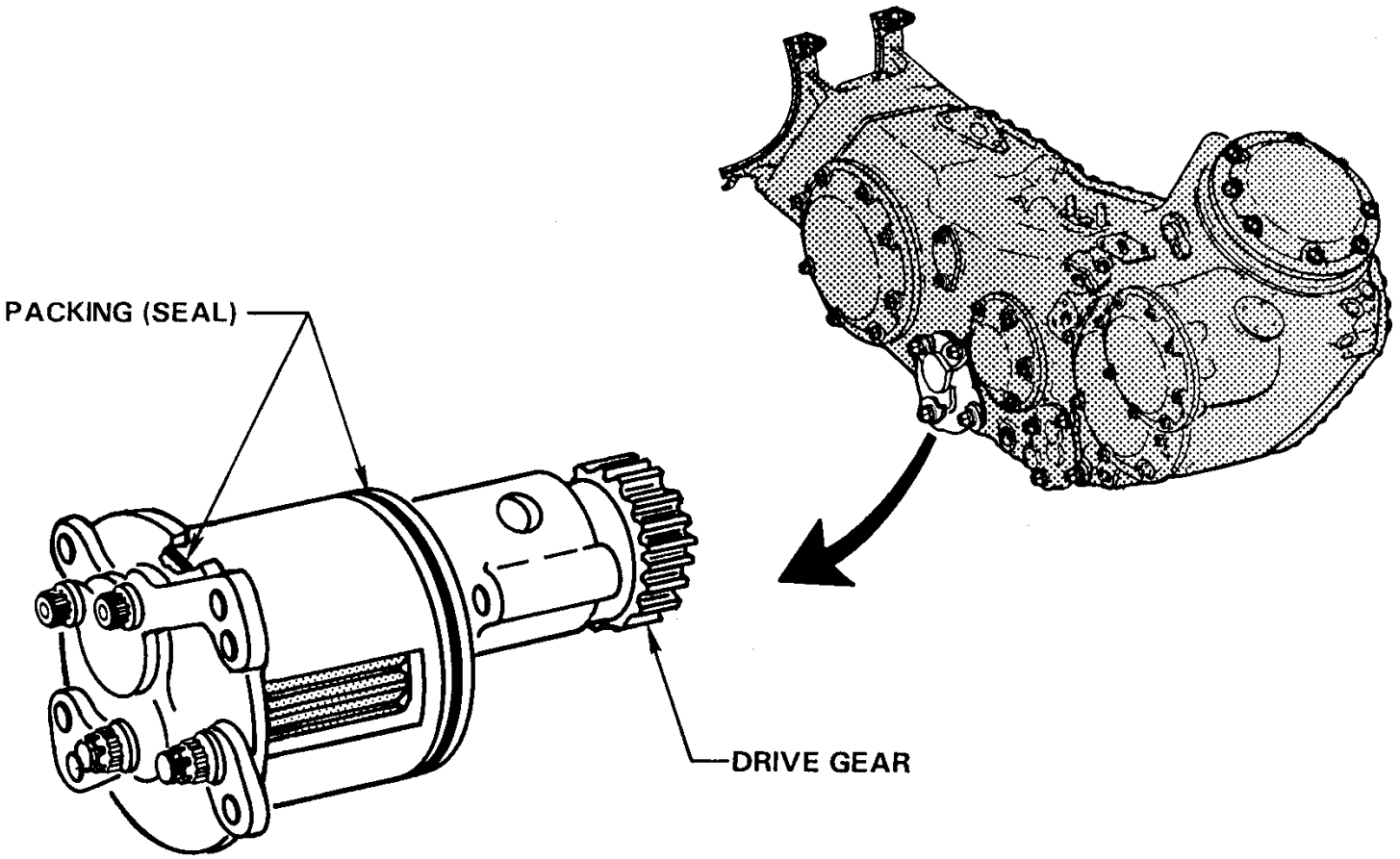
Location:

- The oil pump is found on the rear face of the main gearbox.

Description and Operation:

- Positive displacement
- Gear type

Oil Pump



CT3181.19971009

CT3181

Main Oil Filter

Purpose:

- The main oil filter removes contaminants from the pressurized oil.

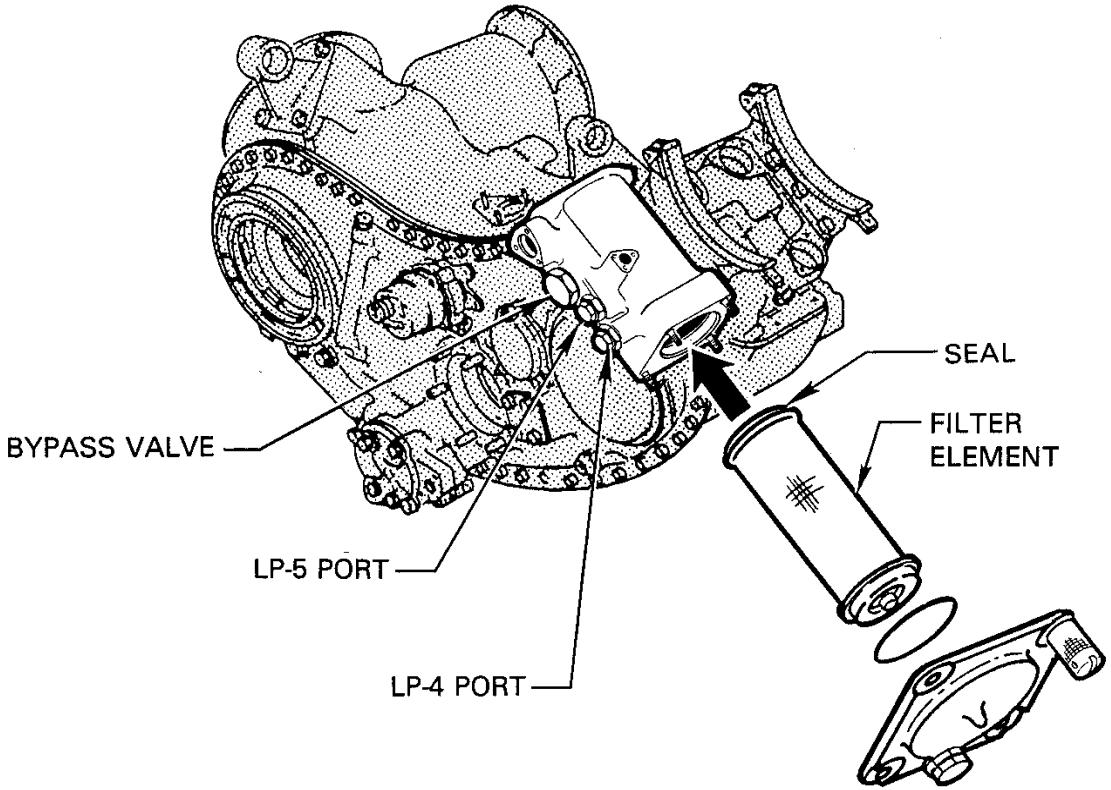
Location:

- The main oil filter is found on the left side of the main gearbox.

Description and Operation:

- Filter element
  - Cartridge type
  - 15 micron, disposable - bill of material
  - 40 micron, ultrasonically cleanable or disposable (optional)
- Filter housing
  - Cored casting
  - Has filter bypass valve (____ psid)
  - ΔP ports
  - Oil discharge port
  - Oil tank locating pin mount pad
- Filter cover
  - Has drain plug, O ring seal, and compression spring
  - Secured by four slotted nuts

Main Oil Filter



CT4056.19971009

CT4056

Oil Filter ÄP Switch

Purpose:

- The oil filter ΔP switch senses differential pressure between the oil filter inlet and outlet.

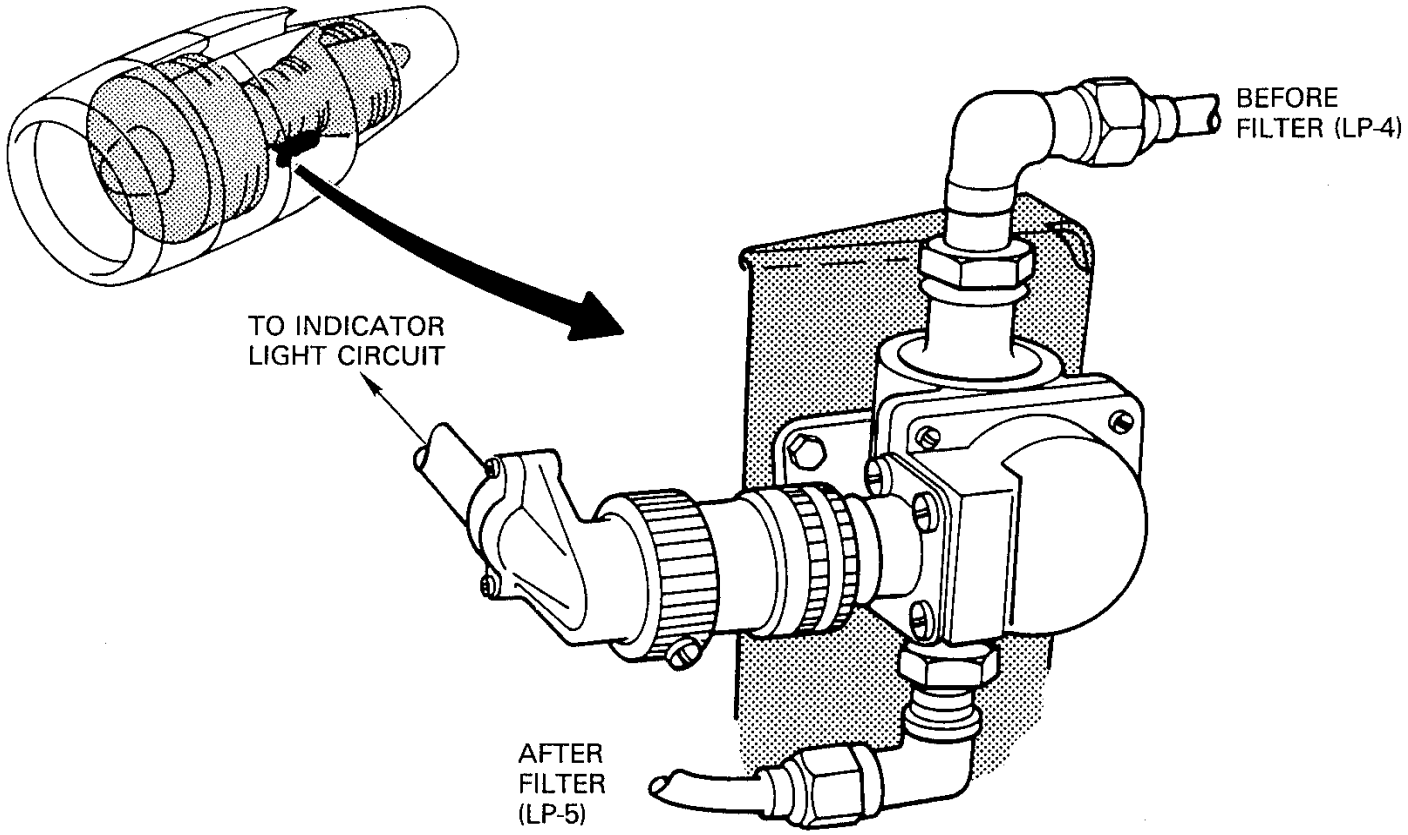
Location:

- The oil filter ΔP switch is found on the lower left side of the core engine, forward of the main gearbox.

Description and Operation:

- Inputs
  - Pressure before filter (LP-4)
  - Pressure after filter (LP-5)
  - 28VDC
- Outputs
  - 28VDC to OIL CLOG light
  - Switch closes if ΔP is >___ psi - increasing
  - Switch opens if ΔP is <___ psi - decreasing

Oil Filter ÄP Switch



CT4057.19971009

CT4057

Oil Pressure Regulating Valve

Purpose:

- The oil pressure regulating valve:
  - Regulates oil pressure and flow to nozzles in the bearing compartments and gearboxes.
  - Compensates for oil filter and oil cooler pressure drops.

Location:

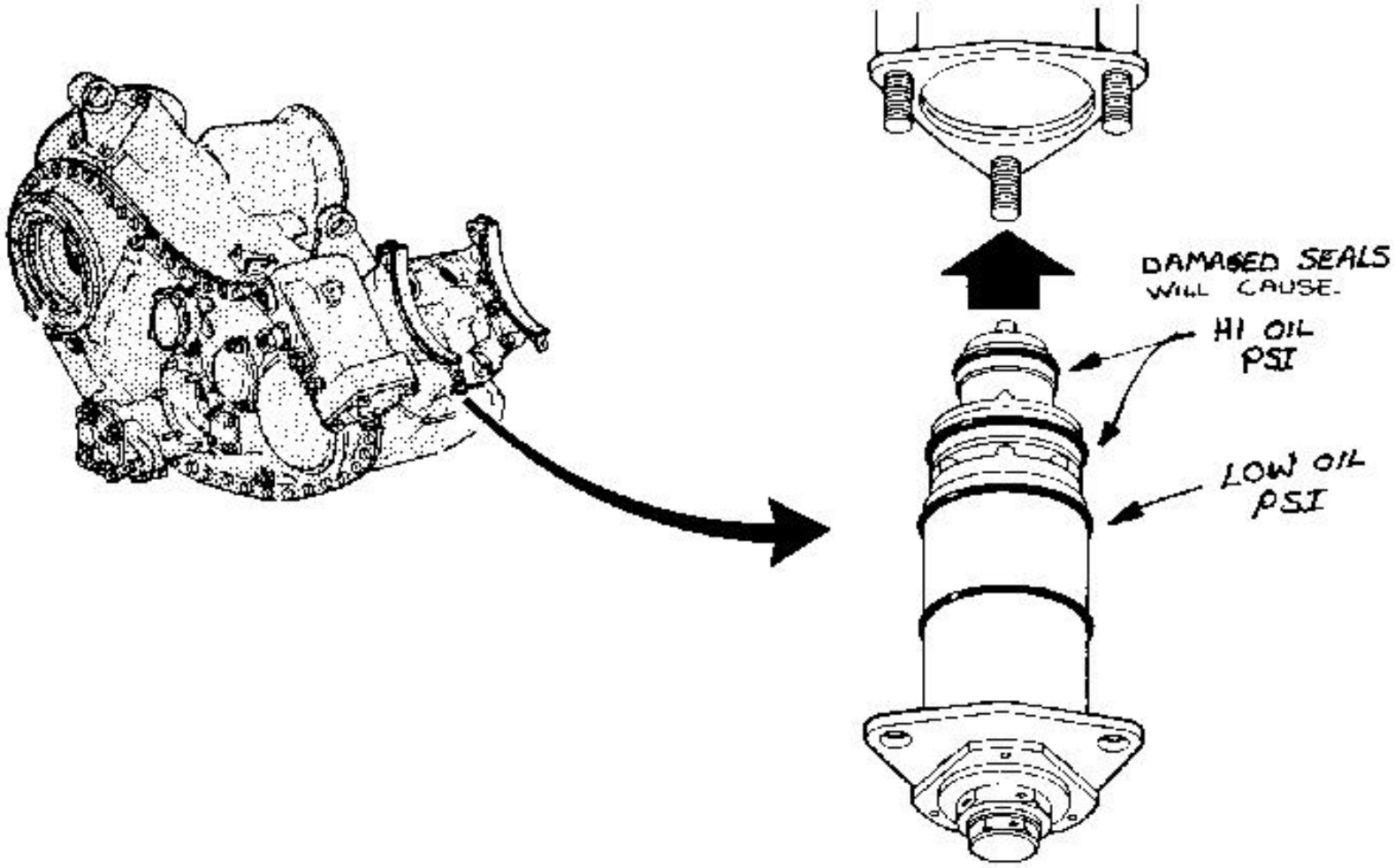
- The oil pressure regulating valve is found on the left side of the main gearbox.

Description and Operation:

- Inputs
  - Pump discharge pressure
  - Pump inlet pressure
  - Sense pressure - downstream of the fuel / oil cooler
  - Spring-loaded closed, oil pressure opened
- Outputs
  - Pressure-regulated oil
  - Bypass to pump inlet
- Adjustment
  - Remove cover plug
  - **Loosen** jam nut
  - Turn adjustment screw clockwise to increase

See A310 AMM 71-00-00 Test No. 7 for adjustment of PRV.

Oil Pressure Regulating Valve



CT4058

Fuel/Oil Cooler

Purpose:

- The fuel/oil cooler maintains the engine oil temperature within operating limits.

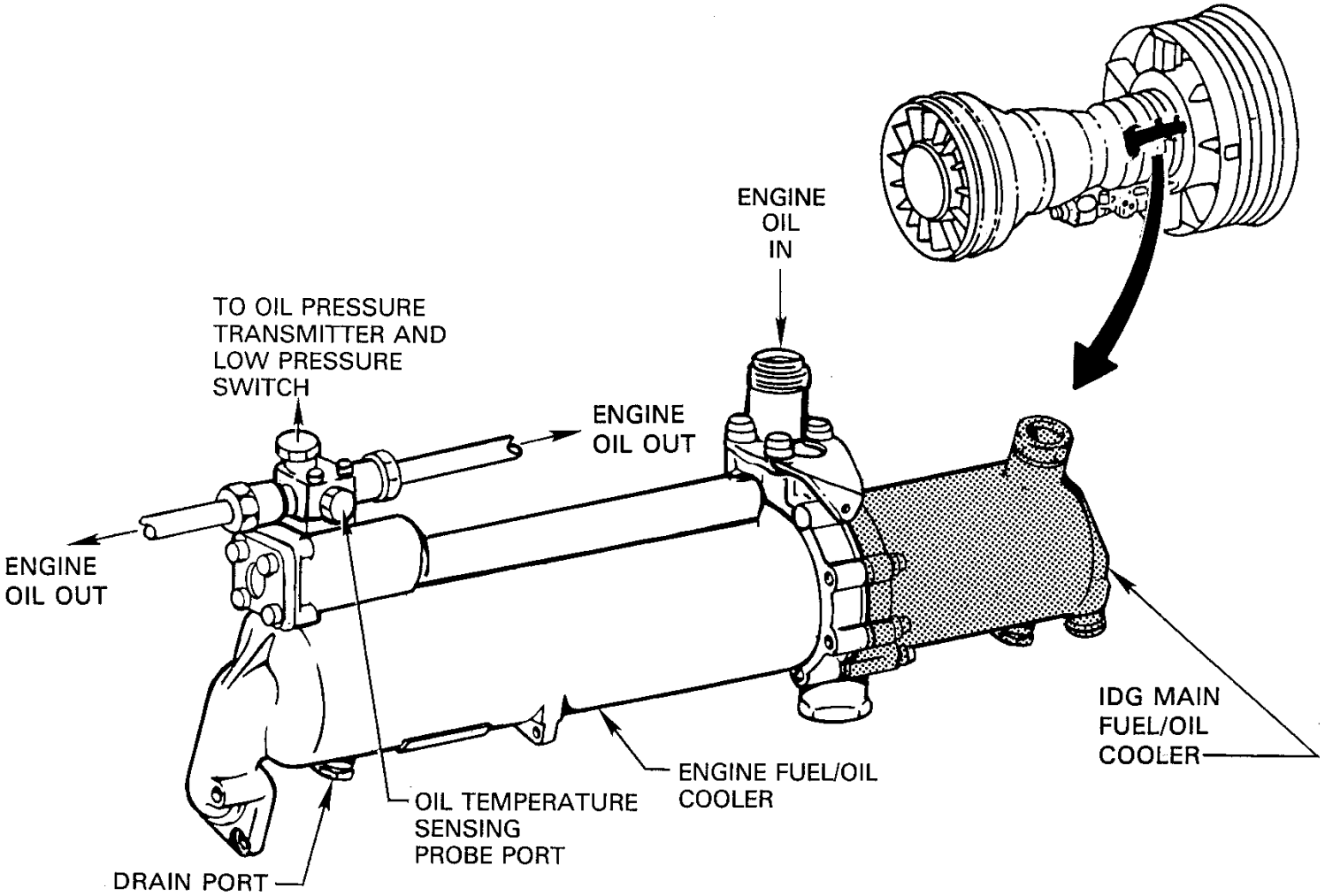
Location:

- The fuel/oil cooler is found on the compressor case at the 2:30 position.

Description and Operation:

- Tubular heat exchanger
- Has bypass valve
- Oil pressure tap
- Oil temperature tap
- Drain port
- Fuel flow transmitter mount pad
- Uses metered fuel as coolant

Fuel/Oil Cooler



CT4017.19971009

CT4017

Oil Pressure Transmitter and Low Pressure Switch

OIL PRESSURE TRANSMITTER

Purpose:

- The oil pressure transmitter gives an electrical signal proportional to oil system pressure.

Location:

- The oil pressure transmitter is found on the oil cooler bracket above the oil cooler at the 2:30 position.

Description and Operation:

- Variable resistance
- 0 - 100 psi range
- Vented to main gearbox

HIGH PRESSURE WARNING

Purpose:

- The high pressure warning gives an electrical signal to the OIL HI PRESS warning light and ENG light on the WLDP with a single chime.

Description and Operation:

- Switch closes at _____psi - increasing
- Switch opens at _____psi - decreasing

LOW PRESSURE WARNING SWITCH

Purpose:

- The low pressure warning switch gives an electrical signal to the OIL LO PRESS warning light and the ENG light on the WLDP with a continuous chime.

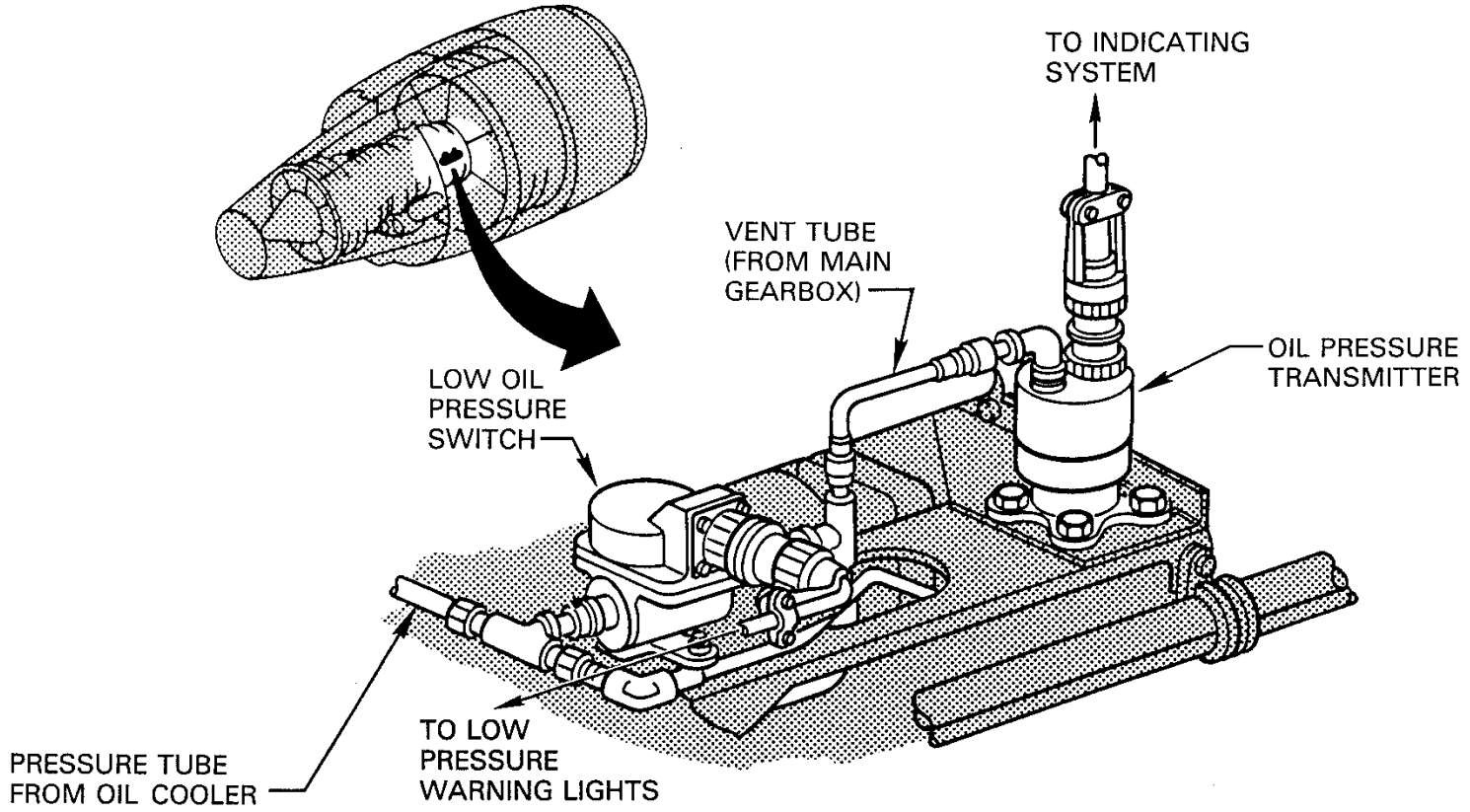
Location:

- The low pressure warning switch is found on the oil cooler bracket.

Description and Operation:

- Switch closes at ___ psi - decreasing
- Switch opens at ___ psi - increasing
- Vented to main gearbox

Oil Pressure Transmitter and Low Pressure Switch


TO INDICATING SYSTEM
VENT TUBE (FROM MAIN GEARBOX)
OIL PRESSURE TRANSMITTER
LOW OIL PRESSURE SWITCH
PRESSURE TUBE FROM OIL COOLER
TO LOW PRESSURE WARNING LIGHTS

CT4060.19971009
CT4060

Scavenge Pumps

Purpose:

- The scavenge pumps are used to send scavenged bearing compartment oil and gearbox oil back to the oil tank.

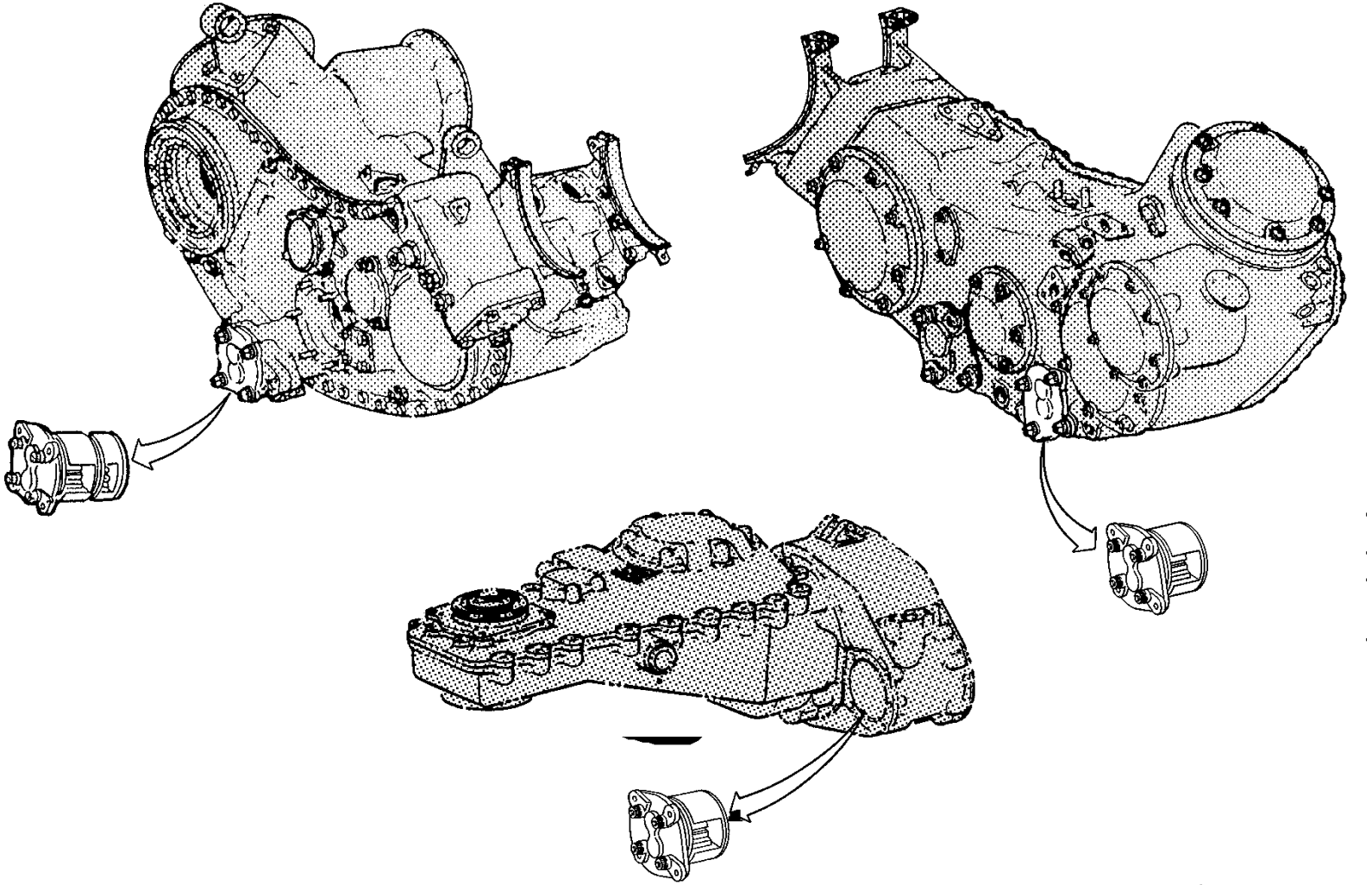
Location:

- The scavenge pumps are found in the angle and main gearboxes.

Description and Operation:

- Angle gearbox scavenge pump sends No. 1 and No. 2 bearing compartment oil from the angle gearbox sump to the oil tank through the main gearbox
- Two pumping elements (housed in a single assembly in the main gearbox) send scavenged oil from the No. 3 and No. 4 bearing compartments to the main gearbox sump where a single-element pump returns the oil to the tank.
- Single-element scavenge pump sends separated oil from the deoiler to the oil tank.

Scavenge Pumps



CT4062.19971010

CT4062

Magnetic Chip Detectors

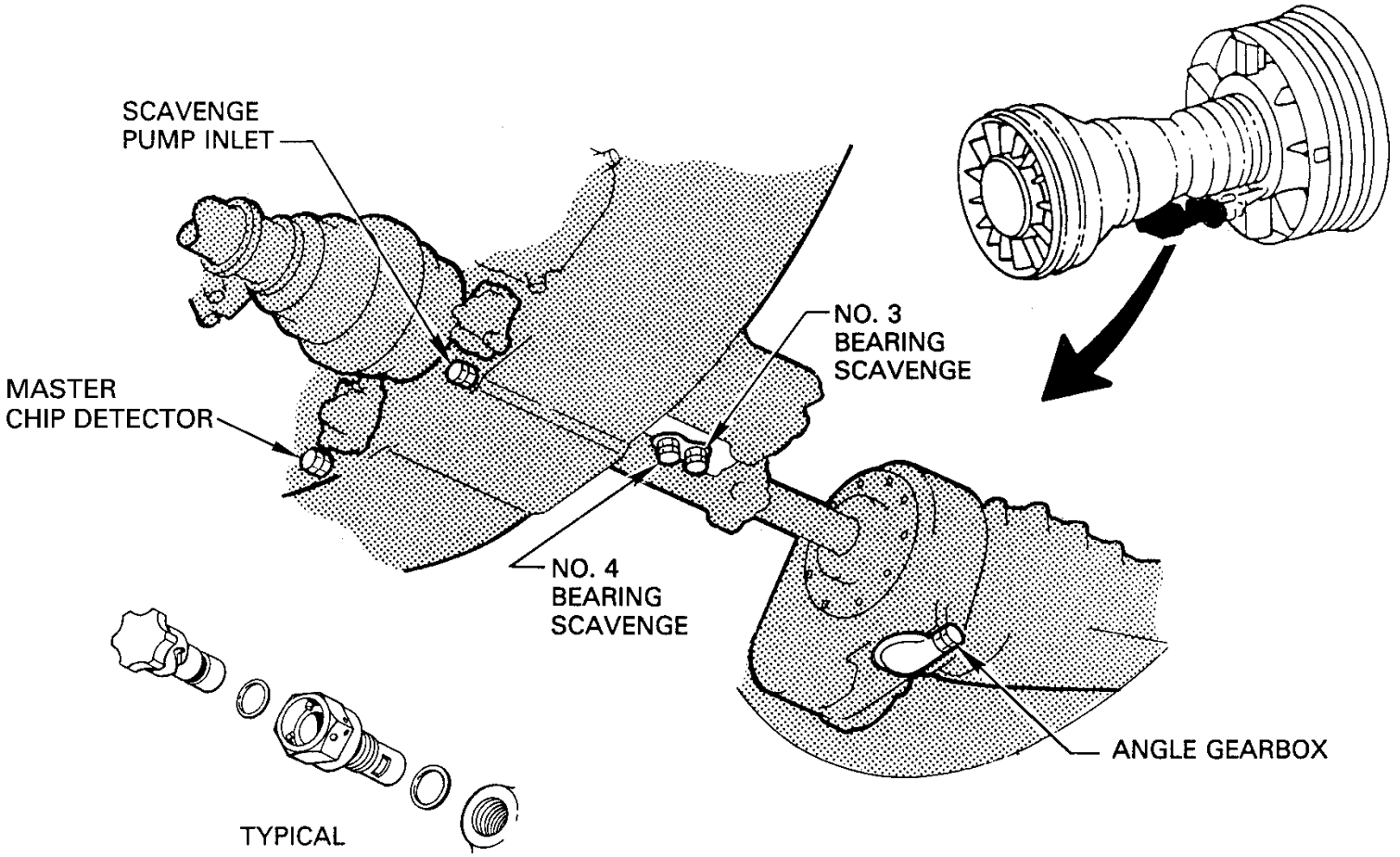
Purpose:

- The magnetic chip detectors are used to collect ferrous metal chips using magnetic detectors. All chip detectors are considered optional equipment.

Location:

- Master chip detector
  - Main oil pump inlet, rear face of the main gearbox
- Gearbox scavenge pump chip detector
  - Scavenge pump inlet, rear face of the main gearbox
- No. 3 bearing compartment scavenge pump chip detector
  - No. 3 bearing scavenge pump inlet
- No. 4 bearing compartment scavenge pump chip detector
  - No. 4 bearing scavenge pump inlet
- Angle gearbox chip detector
  - Angle gearbox (right side)

Magnetic Chip Detectors



CT4063.19971010

CT4063

Deoiler

Purpose:

- The deoiler is used to separate oil mist from breather air.

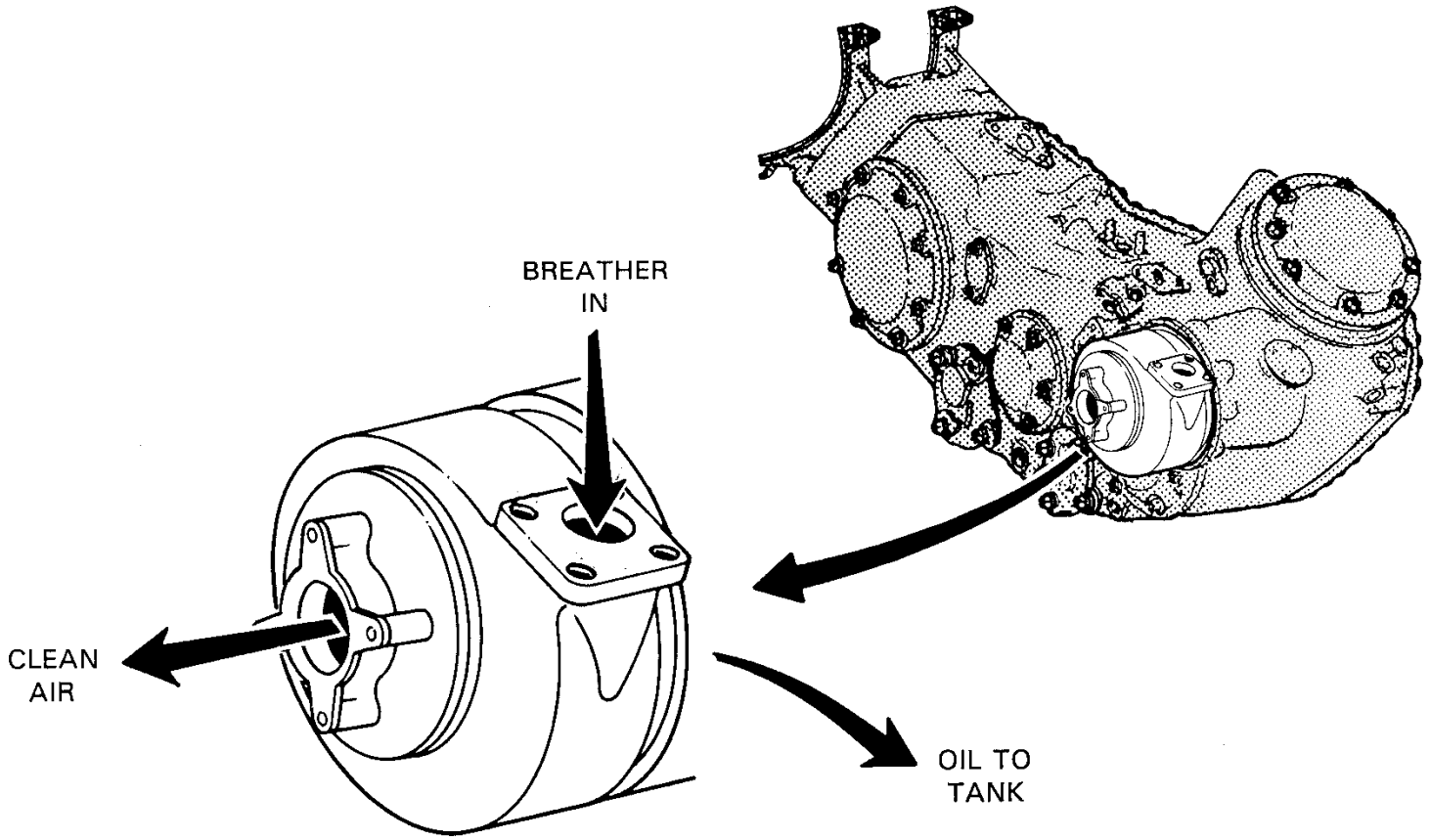
Location:

- The deoiler is found on the right aft side of the main gearbox.

Description and Operation:

- Receives oil-saturated air from the angle gearbox, No. 3 bearing compartment, and the oil tank expansion chamber
- Separates oil from air
- Vents oil-free air overboard

Deoiler



CT4065.19971009

CT4065

Oil System Indication - Quantity

Purpose:

- The engine oil system oil tank quantity probe is used to give the initial and current levels of engine oil.

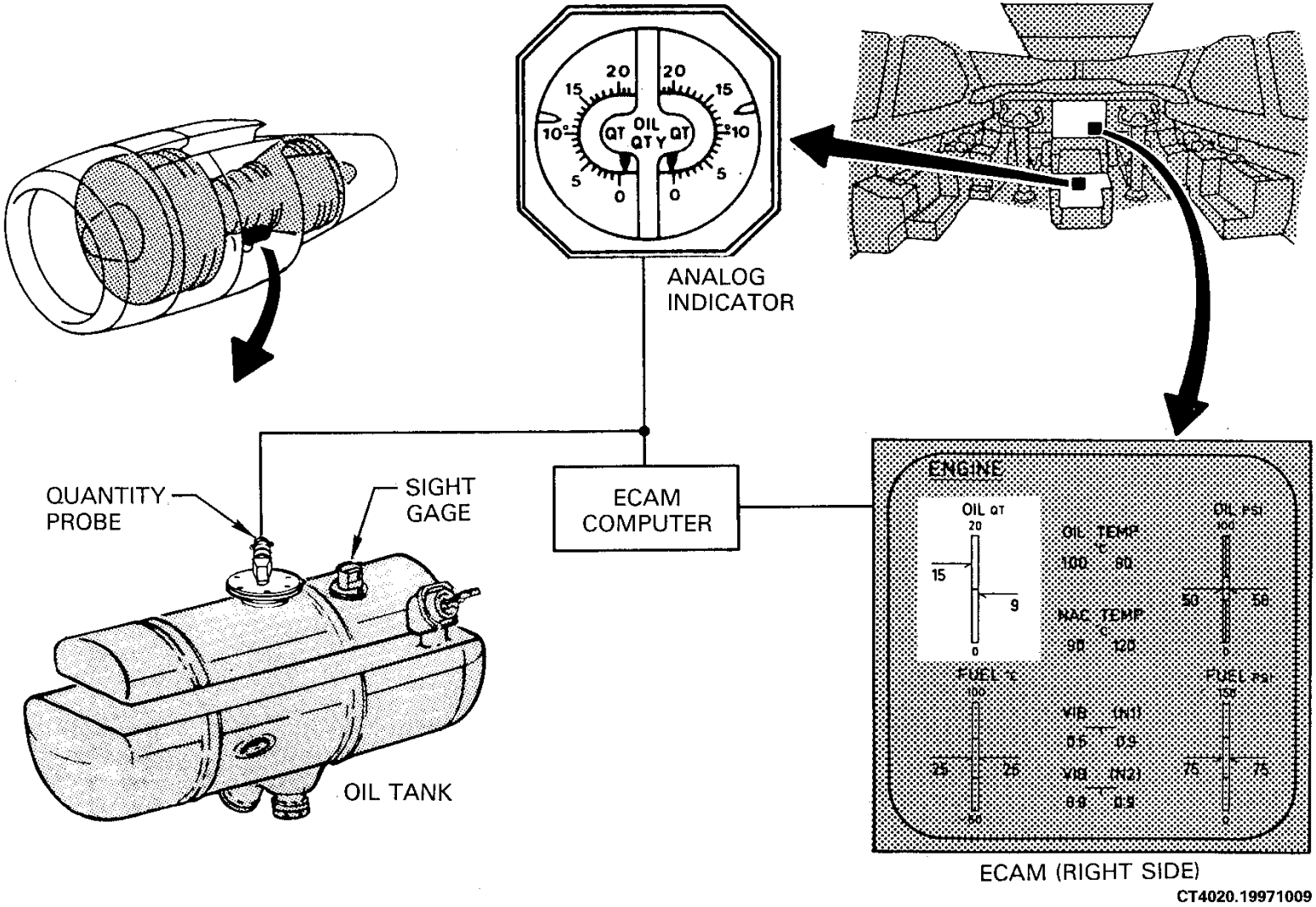
Components:

- Oil quantity transmitting probe
  - Found in the oil tank
- ECAM display
  - Found on the right side of the center display panel
- Analog indicator
  - Found on the forward control pedestal

Description and Operation:

- Powered by 28VDC
- Signals displayed on both analog indicator and ECAM
- Oil quantity transmitter probe
  - Sends analog / digital signal to display units
- Display units
  - ECAM (right side) receives signal from the transmitting probe through the ECAM computer to show current quantity of oil (0-20 quarts) on engine pages and cruise page
  - Analog indicator receives a direct signal from the transmitting probe to indicate initial quantity of oil after servicing and current level of oil (the difference being the amount used)
- Oil quantity warning
  - ECAM engine start page flashes when oil tank quantity indication is < 5 quarts.
  - ECAM engine page flashes when oil tank quantity indication is < 4 quarts.

Oil System Indication - Quantity



CT4020

Oil System Indication - Pressure

Purpose:

- Engine oil system pressure indication is used to give the current status of the engine oil system pressure.

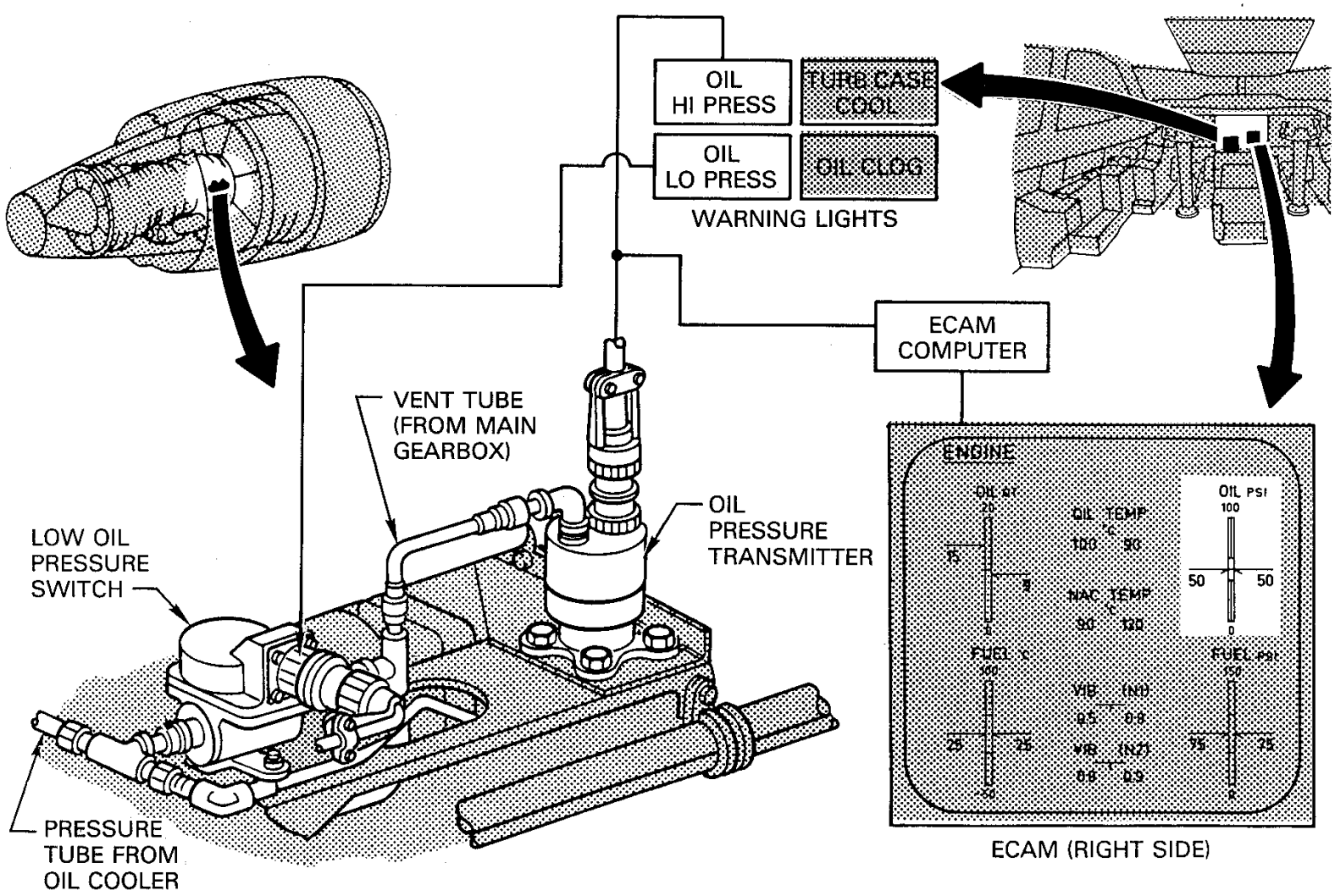
Components:

- Oil pressure transmitter
  - Found above the engine fuel / oil cooler at the 2:30 position
- Low oil pressure switch
  - Found next to the oil pressure transmitter
- ECAM display
  - Found on the right side of the center display panel
- Warning lights
  - Found below the primary engine performance indicators on the center display panel

Description and Operation:

- Signals displayed on warning lights and ECAM
- Oil pressure transmitter
  - Powered by 26V, 400 cycle AC
  - Sends signal to display units
- Low oil pressure switch
  - Powered by 28VDC
  - Sends signal to display units
- Display units
  - ECAM (right side) receives signal from the oil pressure transmitter through the ECAM computer to show current oil pressure (0-100 psi) on engine pages
  - Warning lights receive a direct signal from either the oil pressure transmitter or low oil pressure switch indicating an unacceptable pressure condition
- Oil pressure warning
  - ECAM engine pages flash green ($\leq$ 40 psi) or amber ($\leq$ 35 psi or $\geq$ 60 psi)
  - OIL HI PRESS illuminates amber if psi is > 60
  - OIL LO PRESS illuminates amber if psi is < 35

Oil System Indication - Pressure



CT4018.19971009

CT4018

Oil System Indication - Temperature

Purpose:

- Engine oil system temperature indication is used to give the current temperature of oil leaving the fuel / oil cooler.

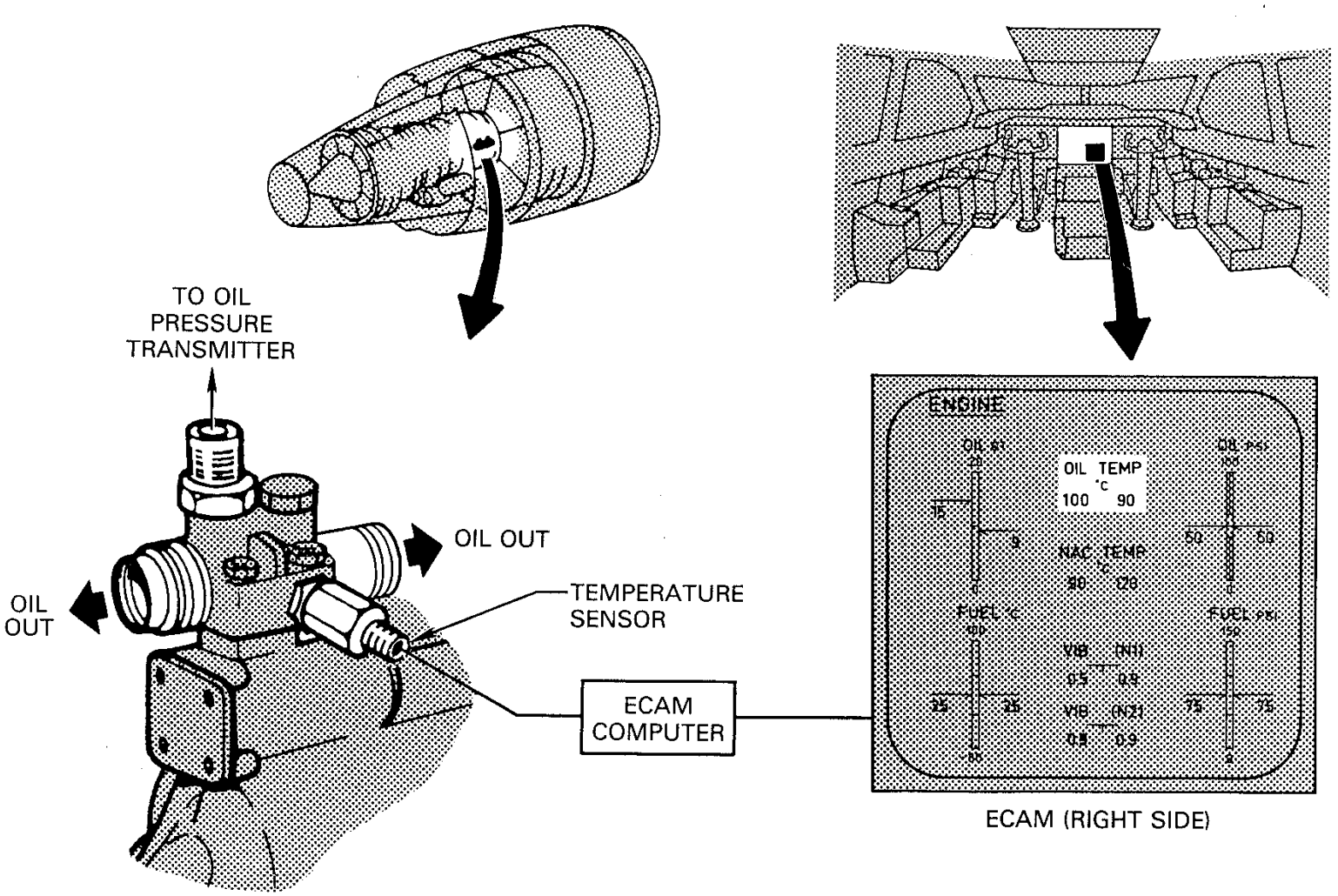
Components:

- Oil temperature sensor
  - Found on top of the engine fuel / oil cooler at the 2:30 position
- Right ECAM display
  - Found on the right side of the center display panel
  - Engine pages

Description and Operation:

- Powered by 28VDC
- Temperature sensor probe
  - Senses temperature of oil exiting the fuel / oil cooler and sends a signal to the ECAM computer
- Display unit
  - ECAM (right side) receives digital signal from the temperature sensing probe through the ECAM computer to show oil temperature in ^{o}C.
- Oil temperature warning
  - Oil temperature display on the ECAM engine pages flashes green if temperature is $\geq$ 135^{o}C or amber if temperature is > 163^{o}C

Oil System Indication - Temperature



CT4030.19971009

CT4030

Oil System Indication - Filter ÄP

Purpose:

- Engine oil system filter differential pressure (ΔP) indication is used to give an abnormal main oil filter pressure differential condition.

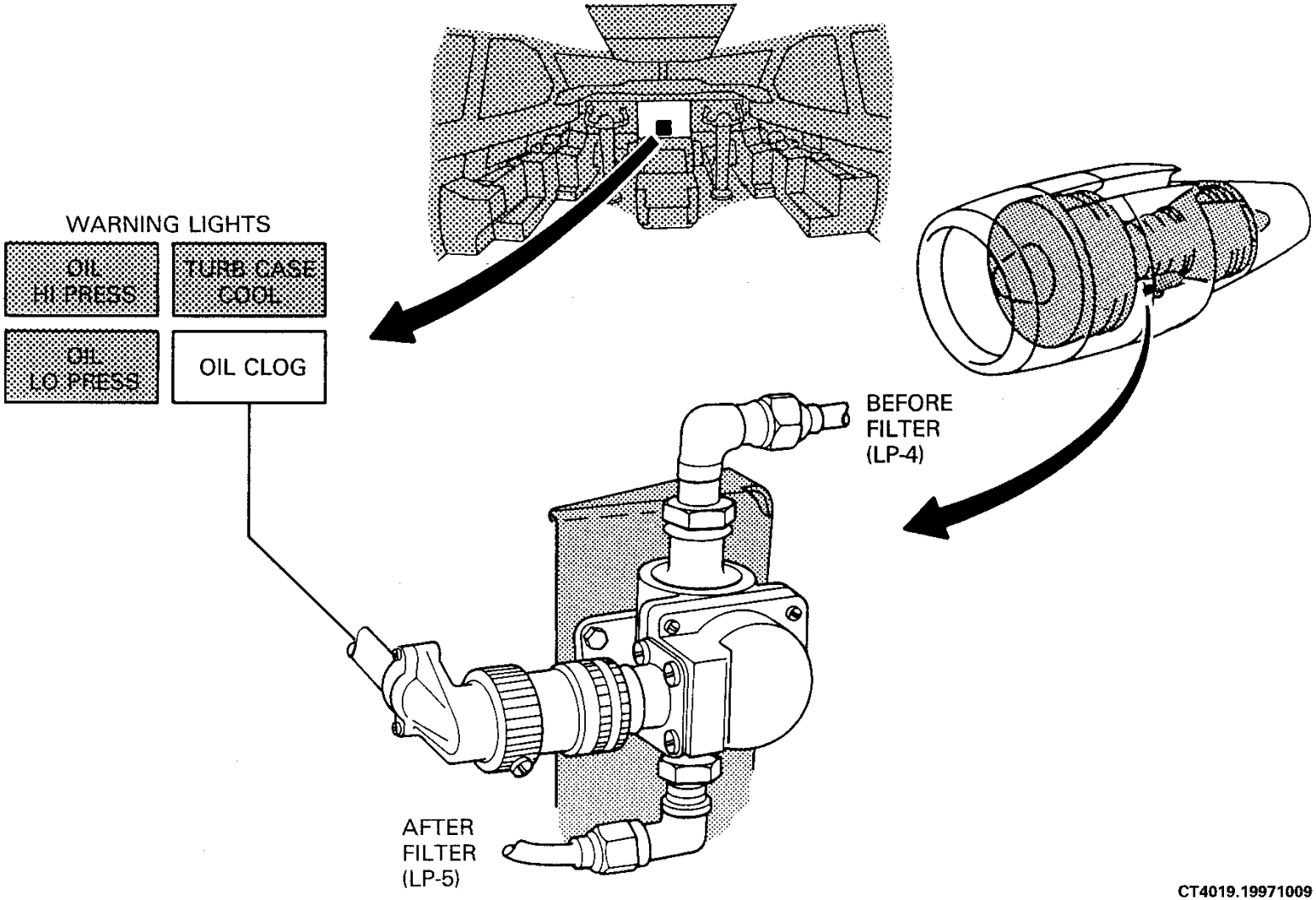
Components:

- Oil filter differential pressure switch
  - Found on the left side of the core engine, forward of the main gearbox
- Warning light
  - Found below the primary engine performance indicators on the center display panel

Description and Operation:

- Powered by 28VDC
- Signal sent to the warning light during an abnormal condition
- Oil filter ΔP switch
  - Senses differential pressure between the main oil filter inlet (LP-4) and outlet (LP-5) and (under an abnormal condition) sends a signal to the warning light
- Display unit
  - Warning light.
- Abnormal conditions
  - OIL CLOG warning light illuminates amber if the oil filter ΔP $\geq$50 psid ($\pm$2)

Oil System Indication - Filter ÄP



CT4019.19971009

CT4019

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PNEUMATIC STARTER SYSTEM

Pneumatic Starter System

GENERAL

Purpose:

- The pneumatic starter system rotates the N2 compressor to get airflow through the gaspath for ground and inflight starts.

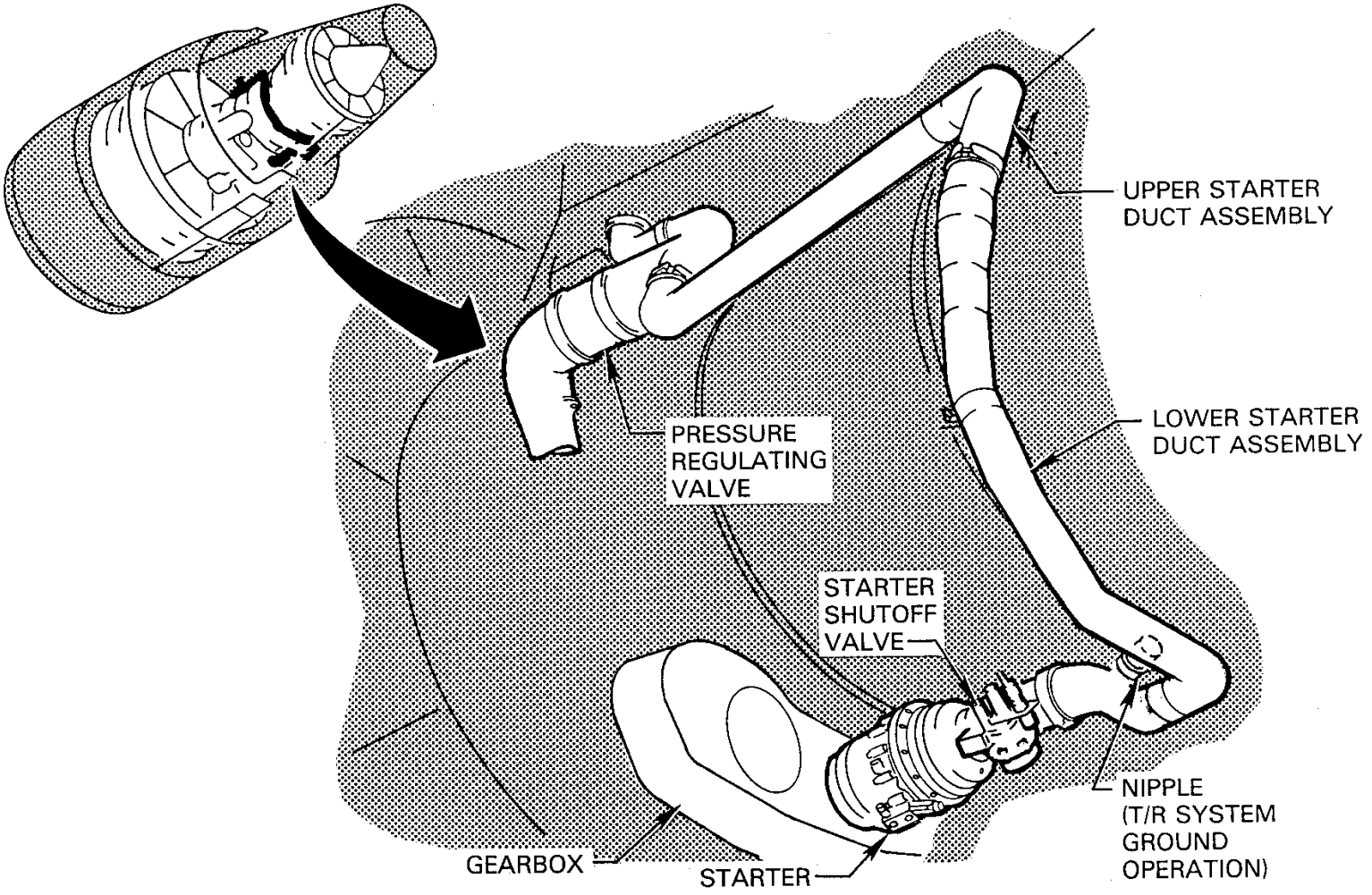
Components:

- Pneumatic starter
  - Mounted on the center drive pad, aft side of the main gearbox
- Starter shutoff valve
  - Mounted in the starter air inlet duct

Description and Operation:

- Air supply sources (through interconnect ducting)
  - Aircraft APU
  - Ground air cart
  - An operating engine
- Shutoff valve opened by start (push) switch in cockpit
- Starter turbine drives N2 through starter reduction gearing and output shaft to main gearbox gear train
- Start valve automatically closes at 45% N2

Pneumatic Starter System



CT4142

Pneumatic Starter Shutoff Valve

Purpose:

- The starter shutoff valve controls the flow of pneumatics to the starter.

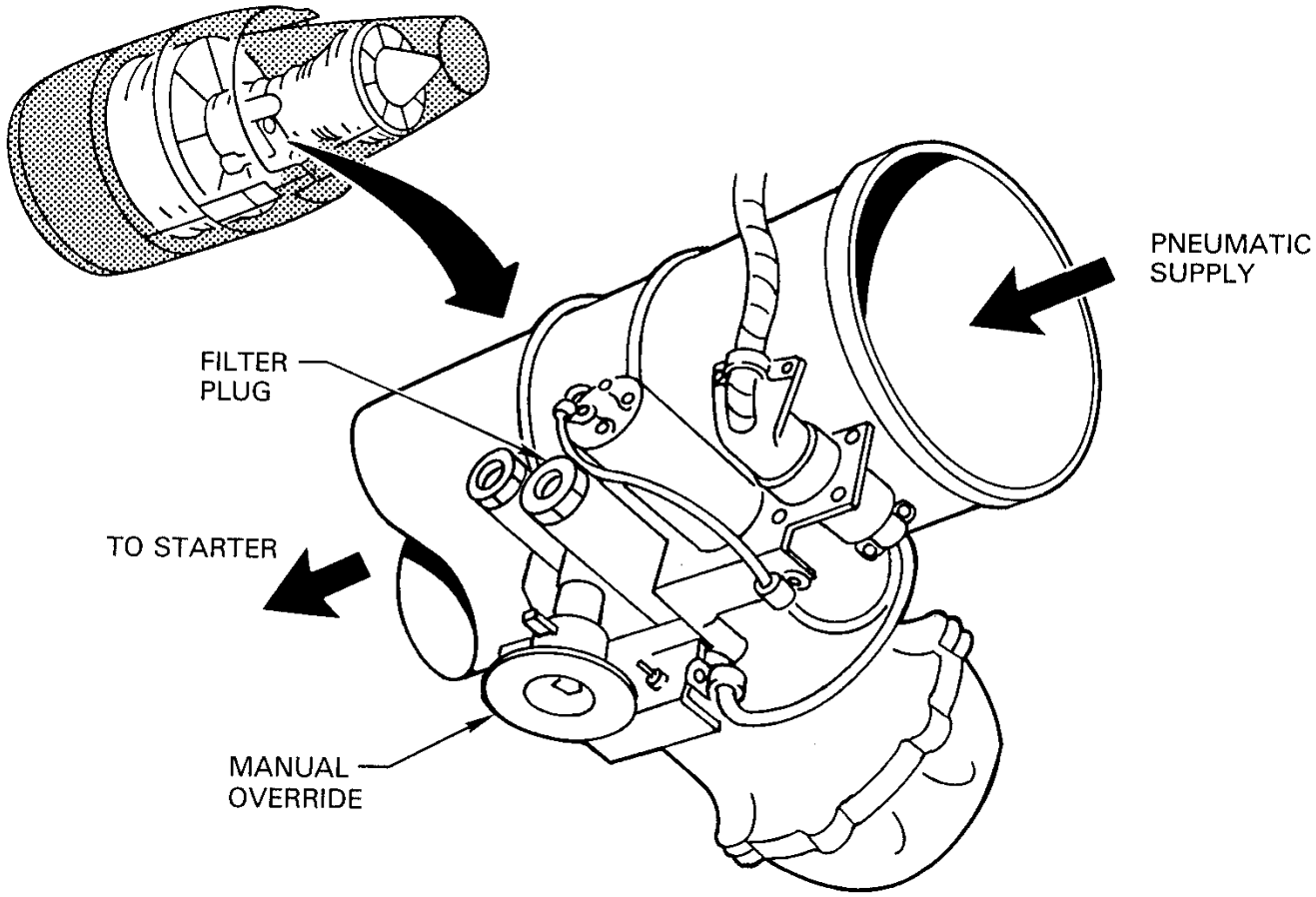
Components:

- The starter shutoff valve is mounted in the starter inlet duct.

Description and Operation:

- Two-position butterfly valve
- Electrically controlled - pneumatically actuated
- Has position indicator
- Has a provision for manual override
- Closes automatically during start at 45% N2

Pneumatic Starter Shutoff Valve



CT4143.19971009

CT4143

Pneumatic Starter

Purpose:

- The starter converts pneumatic pressure and flow to torque to motorize the N2 compressor for ground starting, inflight starting, and dry / wet motoring for maintenance and troubleshooting.

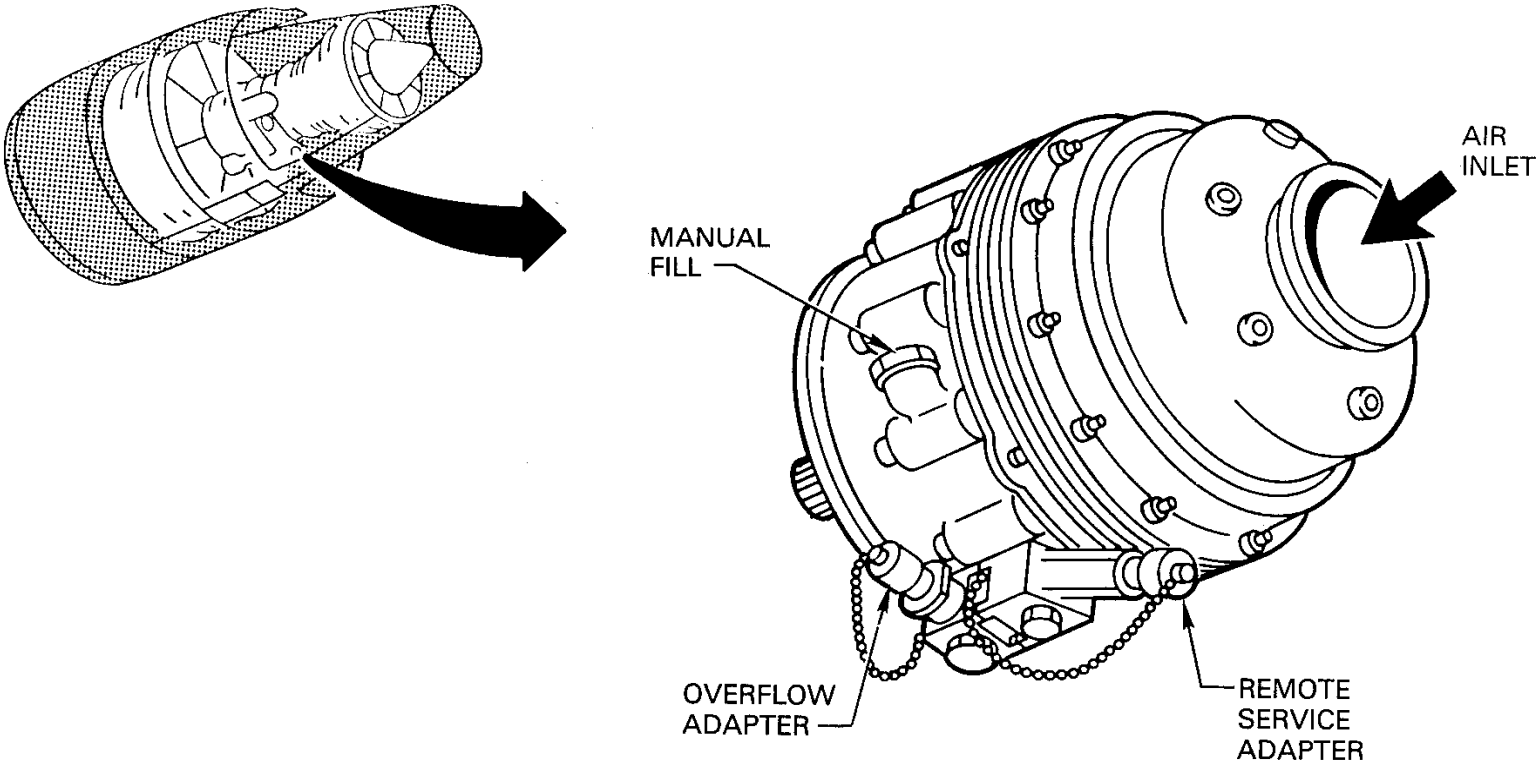
Components:

- The starter is mounted on the rear face of the main gearbox.

Description and Operation:

- Air turbine starter
- Integral gear train and lubrication system
- Containment case
- Magnetic drain plug
- Oil level sight gage

Pneumatic Starter



CT4144.19971009

CT4144

Starter System Control and Indication

CONTROL - START PANEL SWITCHES

Purpose:

- The start panel switches permit controlling the starter shutoff valve, ignition system arming, and fuel enrichment for cold day starting.

Components:

- The start panel switches are found on the center overhead panel.

Description and Operation:

- ENRICH push-button
  - Drives the high pressure fuel shutoff valve actuator to ENRICH position to give 100 pph additional fuel flow for cold day start enrichment
- START 1 and START 2 push-buttons
  - Engine start page - right CRT
  - Pack valves closed
  - Fuel used - zeroed
  - Starter shutoff valve open
  - APU speed increases
  - Flight recorder ON
- Selector switch
  - START A, START B, and CONT RELIGHT
    - Selects ignition system
  - OFF
    - Starter, ignition, and enrich inhibited
  - CRANK
    - Used for dry or wet motoring
    - Ignition inhibited
    - Start valve permissive for selected engine

INDICATION - ENGINE START PAGE

Purpose:

- The engine start page gives an indication of selected engine parameters during engine start
  - Oil quantity, temperature, and pressure
  - Bleed air duct pressure
  - N1 and N2 vibration
  - Fuel pump interstage pressure

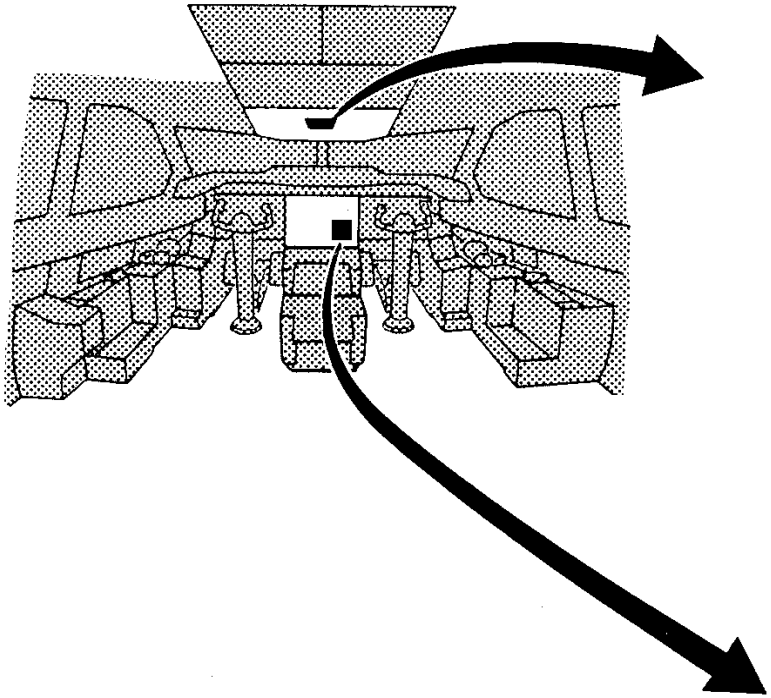
Location:

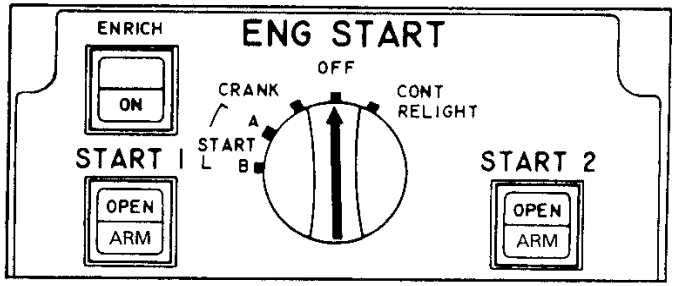
- The engine start page is displayed on the right CRT (ECAM)

Description and Operation:

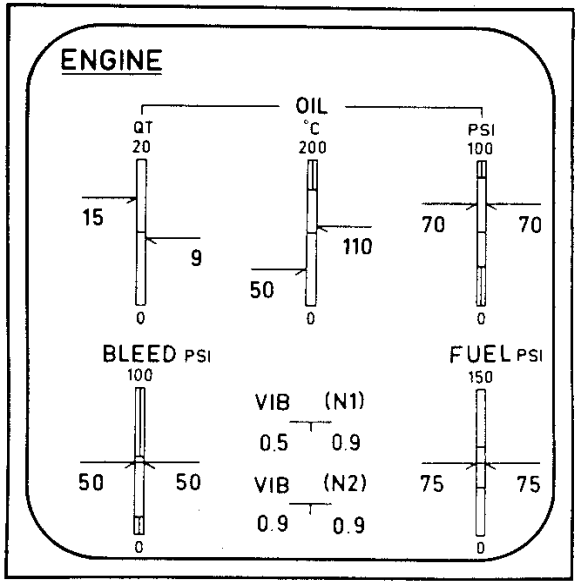
- Automatically displayed on right CRT when START 1 or START 2 switch is pushed
- Automatically replaced by ENGINE PAGE at starter cutout (45% N2)

Starter System Control and Indication





START PANEL



ENGINE START PAGE

CT4145.19971009

CT4145

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IGNITION SYSTEM

Ignition System

GENERAL

Purpose:

- The ignition system gives a high energy spark to ignite the fuel / air mixture in the combustor.

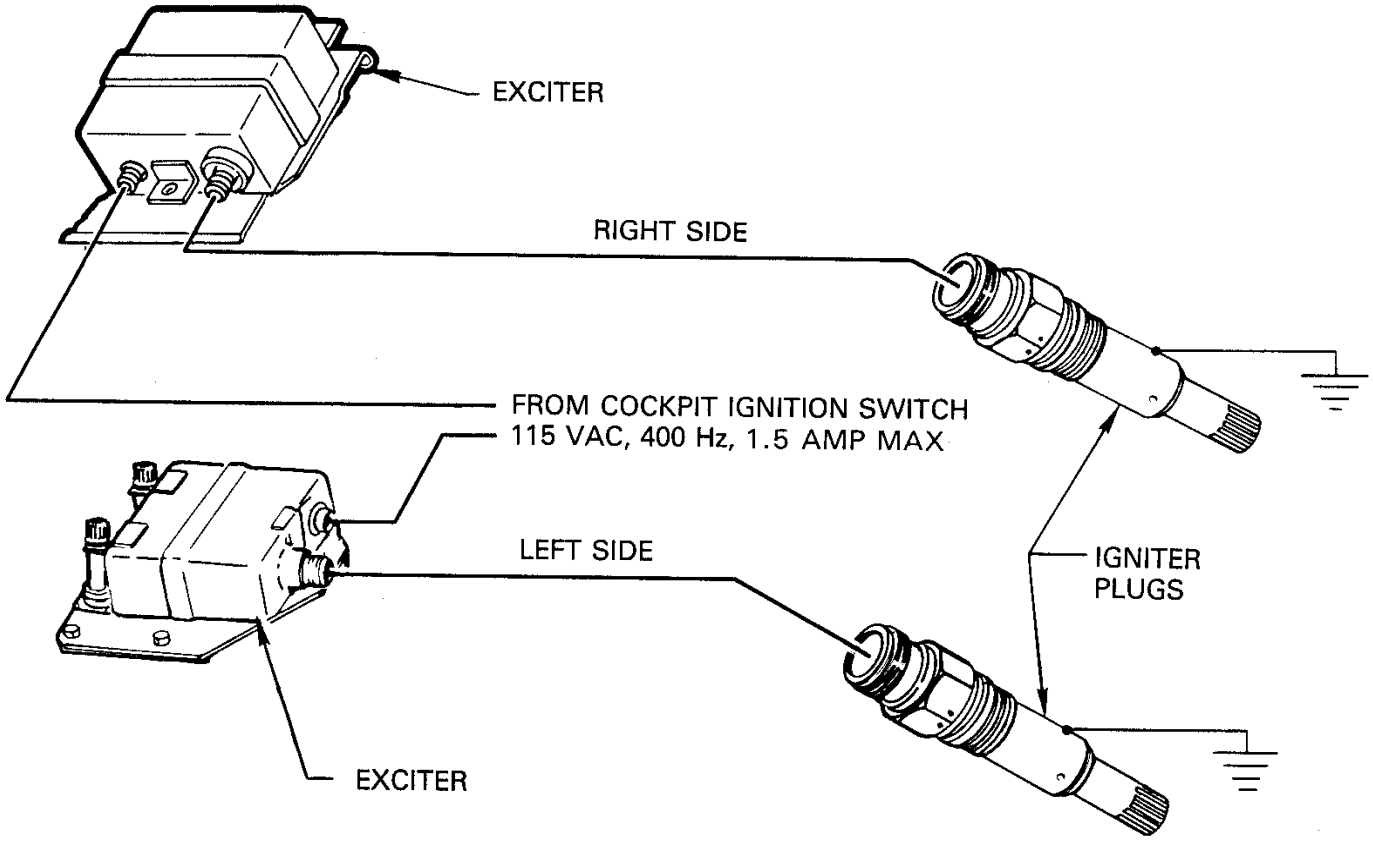
Components:

- Exciter
- High tension leads
- Igniter plugs

Description and Operation:

- Two independent systems
  - Right side exciter - high tension lead and igniter plug
  - Left side exciter - high tension lead and igniter plug
  - Either or both may be selected for ground and / or air start
- 115VAC, 400Hz, 15AMP (maximum) input
- 4 joule energy rating

Ignition System



CT3182.19971009

CT3182

Ignition System Components

EXCITERS

Purpose:

- Exciters are used to convert aircraft electrical power to high energy spark at igniter plugs.

Location:

- Left side
  - Attached to the PIH heater
- Right side
  - Attached to the lower right 3.5 bleed valve

Description and Operation:

- Four joule - stored energy
- 115VAC - 400 Hz input
- 1AMP - nominal
- 2 sparks per second
- Continuous duty cycle
- Fan air cooled

HIGH TENSION LEADS

Purpose:

- The high tension leads are used to transfer electrical energy from the exciters to the igniter plugs.

Location:

- The high tension leads are found on the right and left sides of the core engine.

Description and Operation:

- Encased in a protective braided shield
- Ceramic insulated terminals
- Fan air cooled

IGNITER PLUGS

Purpose:

- The igniter plug is used to convert high energy output from the exciters to a high intensity spark.

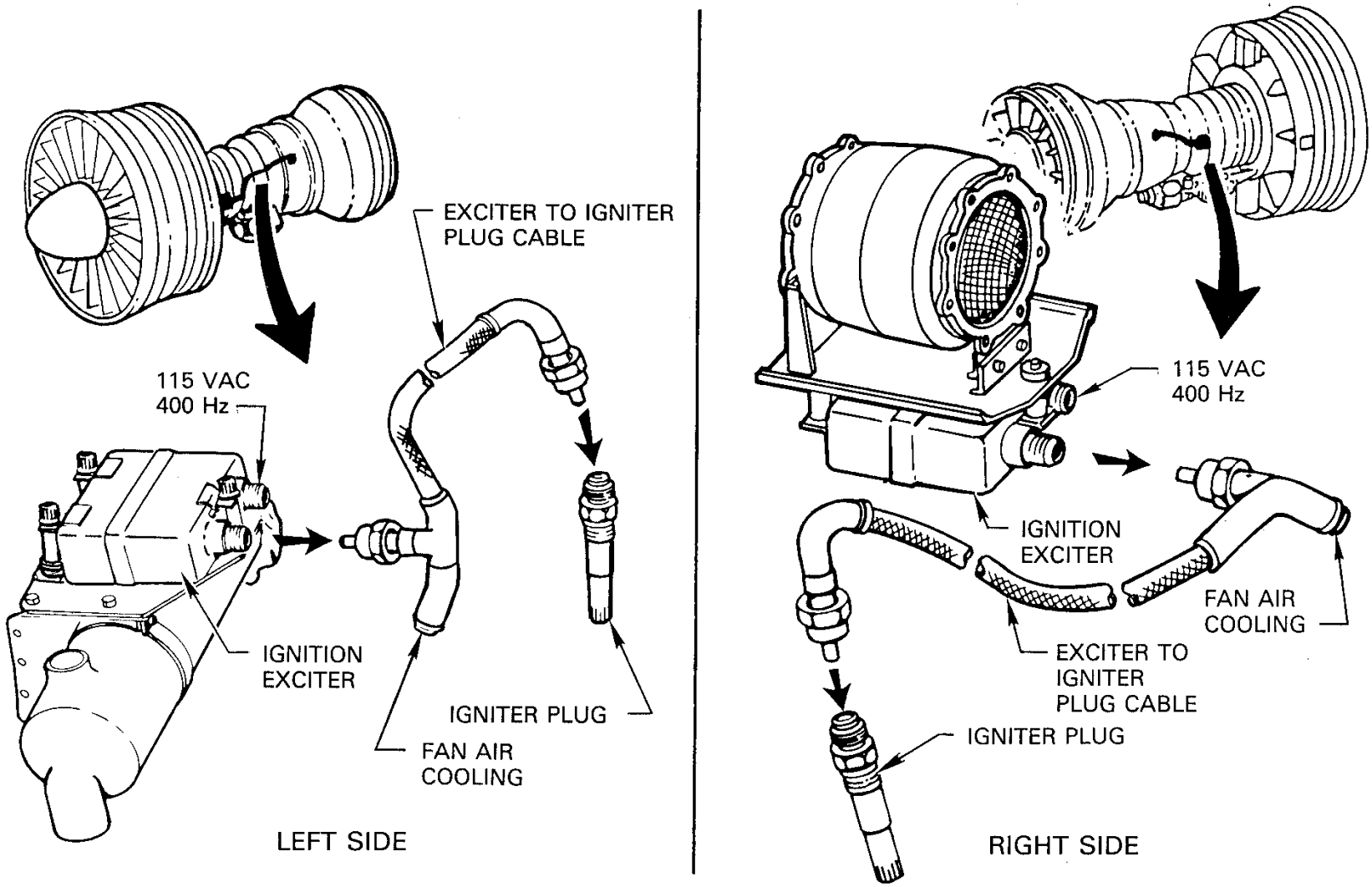
Location:

- The igniter plugs are found on the diffuser case at the 2:30 and 9:30 positions.

Description and Operation:

- Ionizing gap
- Shielded electrode center
- Classified spacer(s) sets depth of penetration
- Air cooled

Ignition System Components



CT4146

Ignition Cooling Ducts

Purpose:

- Ignition cooling ducts are used to supply continuous air cooling of the ignition system components.

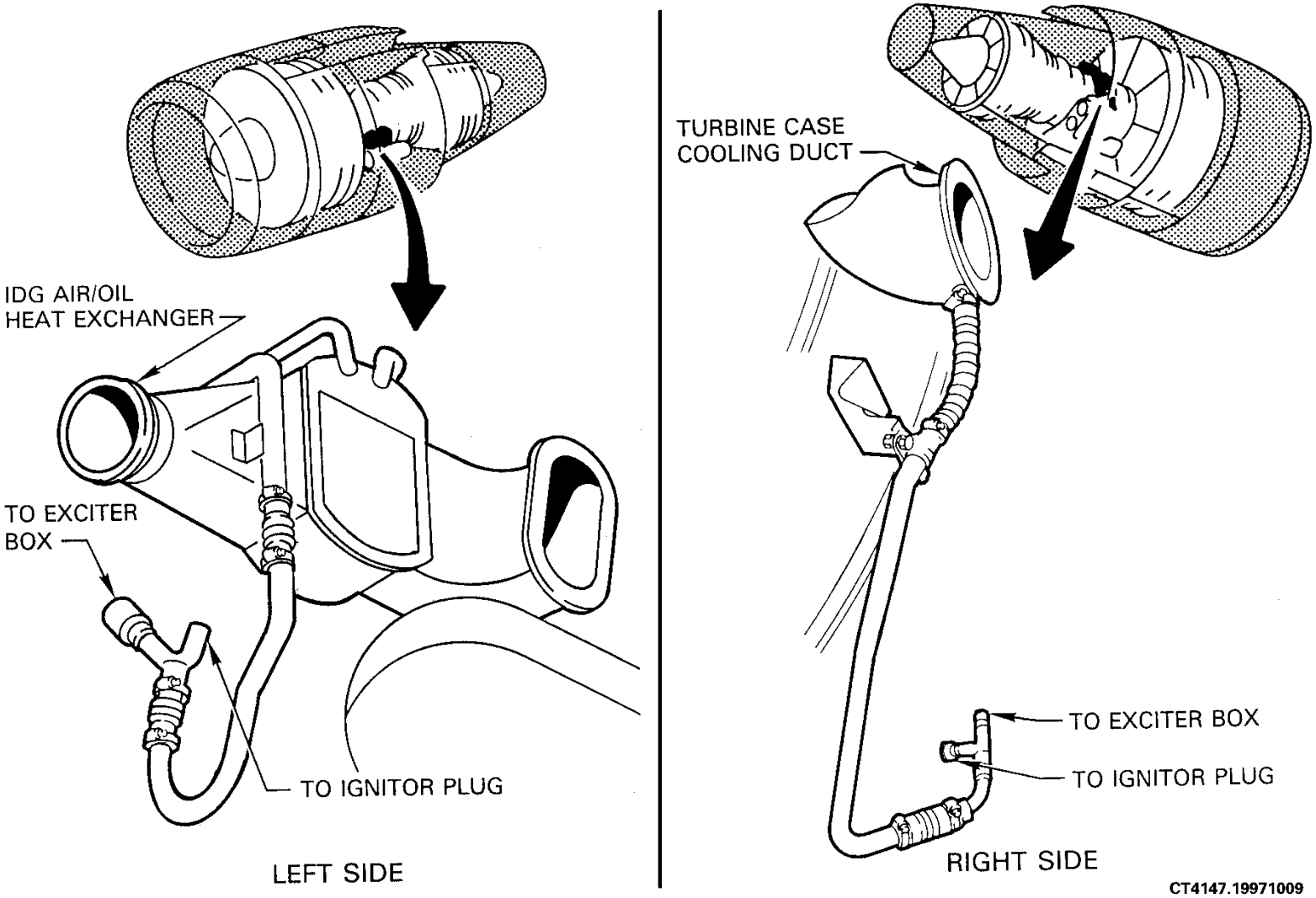
Location:

- The cooling ducts are found on the core engine - left and right side.

Description and Operation:

- Rigid and flexible tubing
- Fan air cooling through
  - Automatic Rotor Clearance Control System fan air duct - right side
  - IDG air/oil heat exchanger - left side

Ignition Cooling Ducts



CT4147

Ignition System - Selection and Control

SELECTOR SWITCH

Purpose:

- The selector switch permits control of the ignition system and starting system circuits and components.

Location:

- The selector switch is found on the overhead panel - center.

Description and Operation:

- OFF
  - Inhibits operation of the right and left ignition systems
- CRANK
  - Inhibits operation of the right and left ignition systems
    - **Note**: Starter shutoff valve operation not inhibited
- START A or START B
  - Selects system A or B for starting
  - Arms selected system
- CONT RELIGHT
  - Selects and arms systems A and B
  - Used for continuous ignition in flight

HIGH PRESSURE FUEL SHUTOFF LEVERS

Purpose:

- The high pressure fuel shutoff levers:
  - Control the high pressure fuel shutoff valve actuator position to turn fuel flow to the combustor ON or OFF.
  - Activate the ignition system.

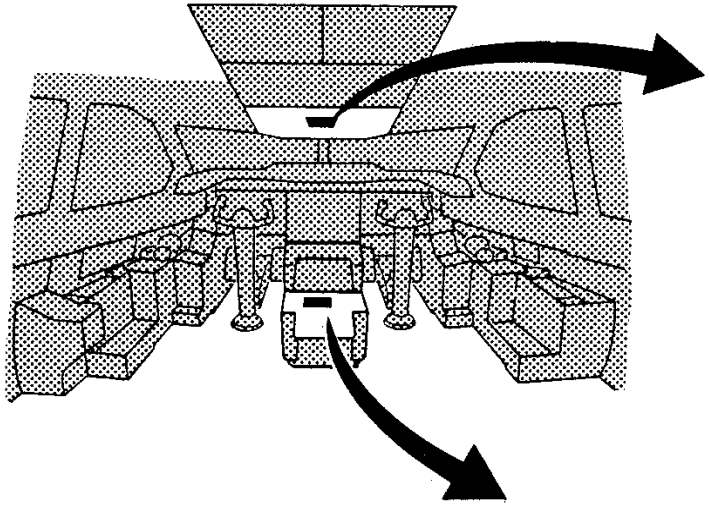
Location:

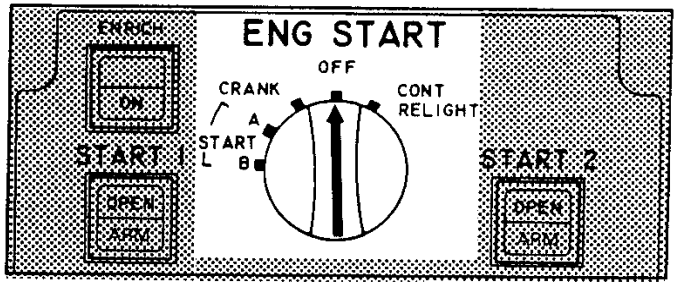
- The high pressure fuel shutoff levers are found on the center pedestal.

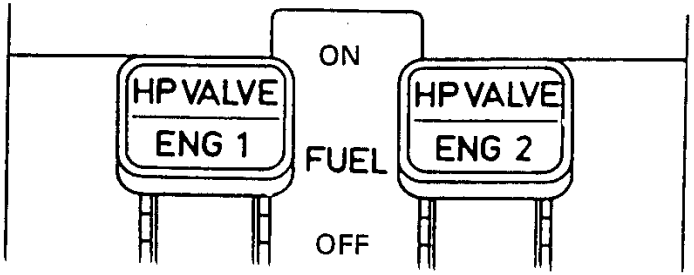
Description and Operation:

- Two positions
  - ON
    - Permits metered fuel to flow to the combustion chamber
    - Completes arming of the selected ignition system
  - OFF
    - Terminates fuel to the combustion chamber
    - Inhibits ignition

Ignition System Selection and Control







CT4148.19971009

CT4148

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INLET COWL AND ENGINE PRESSURE PROBES ANTI-ICING SYSTEM

Inlet Cowl Anti-ice System

GENERAL

Purpose:

- The inlet cowl and engine pressure probes anti-icing system stops the formation of ice on the inlet cowl lip.

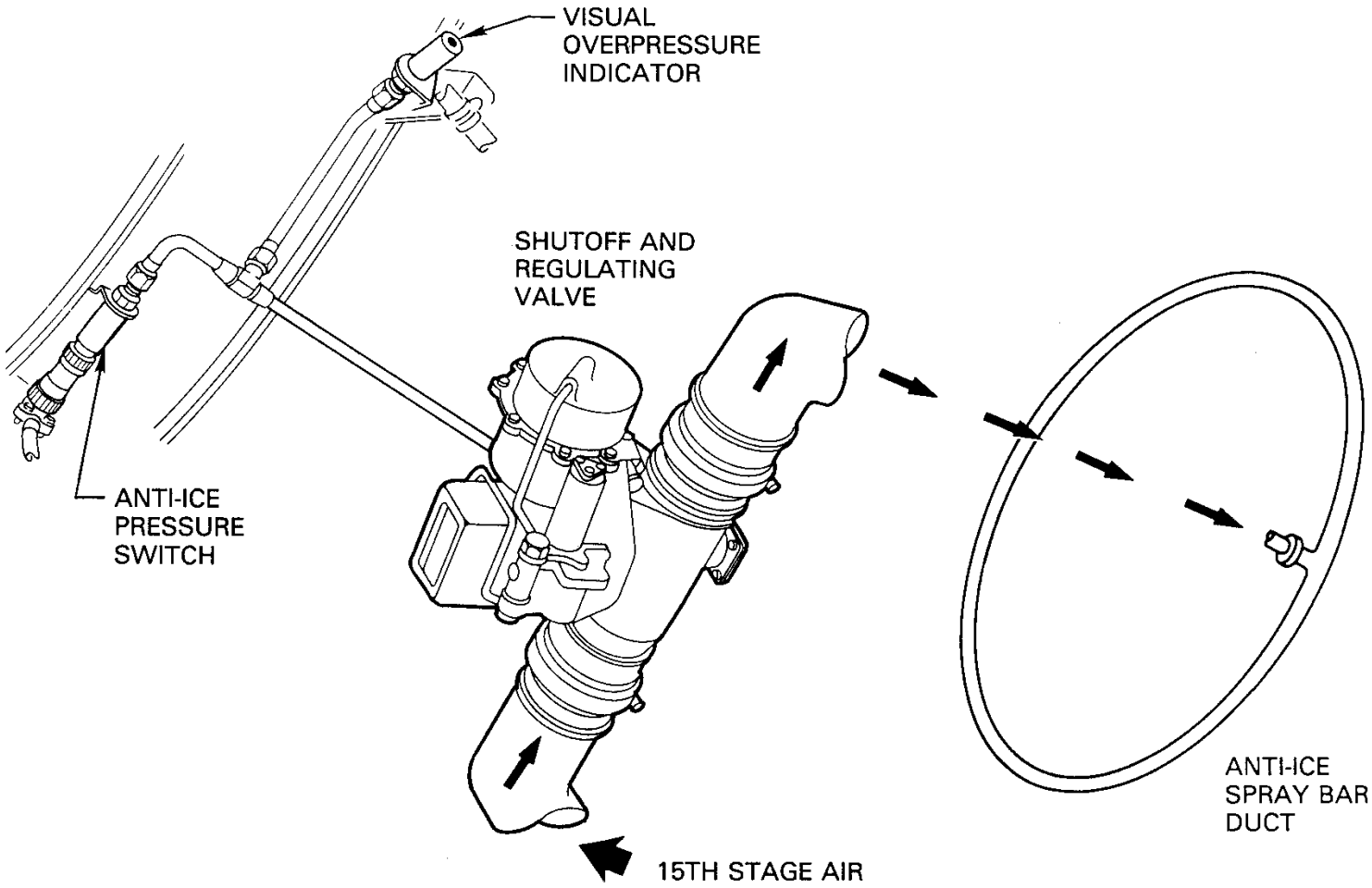
Components:

- Anti-icing spray bar duct
- Shutoff and regulating valve
- Visual overpressure indicator
- Anti-ice pressure switch

Description and Operation:

- Regulated 15th stage air used for anti-icing
- Airflow controlled by the shutoff and regulating valve
  - Electrically controlled by cockpit switches
  - Pneumatically actuated
- Spray bar duct located immediately behind the inlet cowl lip
- Air is discharged overboard on the inlet cowl at the 6:00 position

Inlet Cowl Anti-ice System



CT4116.19971009

CT4116

Inlet Cowl Anti-Ice System Component Locations

Shutoff and Regulating Valve:

- The shutoff and regulating valve is found on the fan case at the 5:00 position.

Pressure Switch

- The pressure switch is found immediately aft of the shutoff and regulating valve.

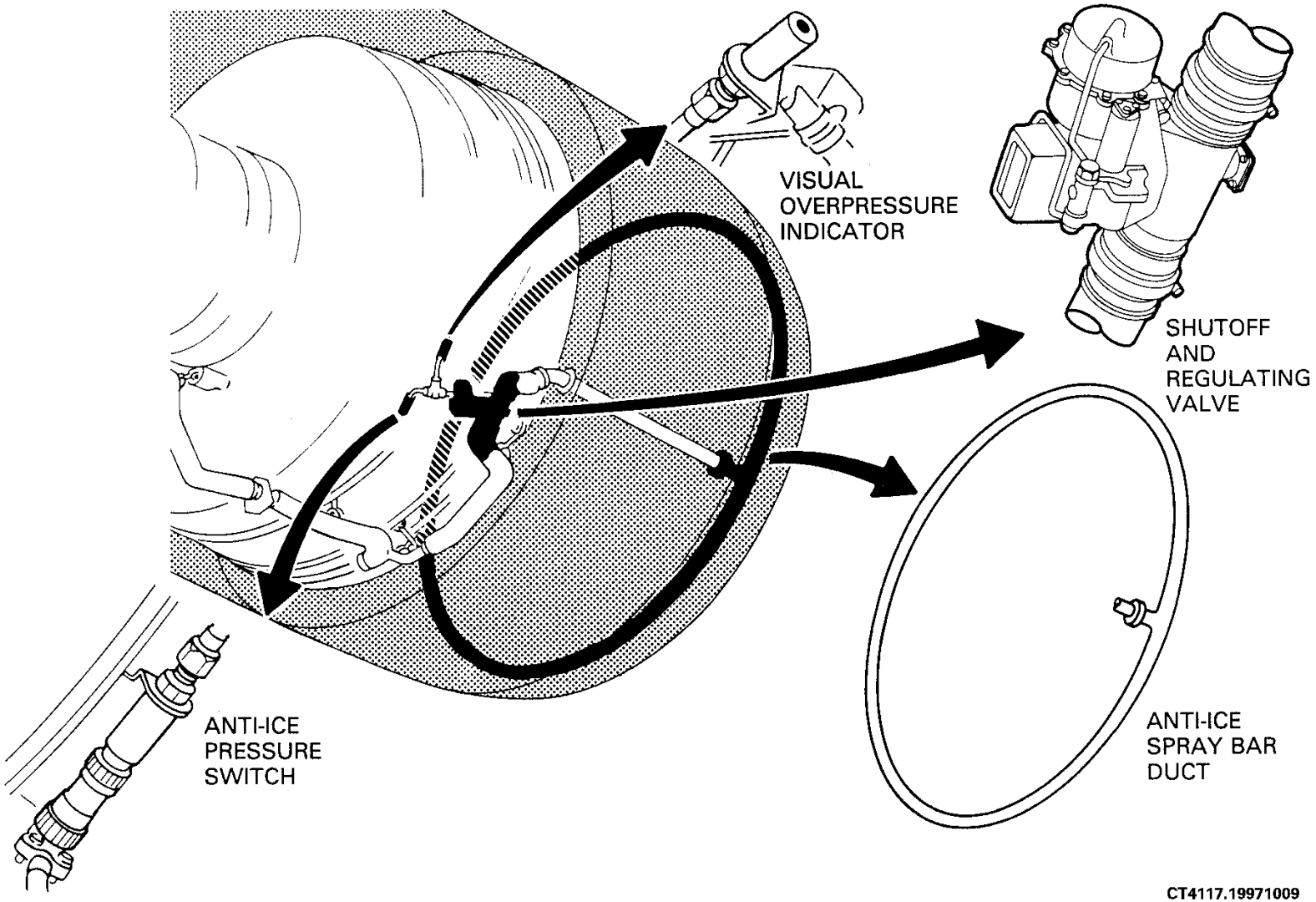
Visual Overpressure Indicator

- The visual overpressure indicator is found immediately aft and above the shutoff and regulating valve.

Anti-ice Spray Bar Duct

- The 360^{o} anti-ice spray bar duct is found in the inlet cowl forward lip

Inlet Cowl Anti-Ice System Component Locations



CT4117.19971009
CT4117

Inlet Cowl Anti-Ice System Components

SHUTOFF AND REGULATING VALVE

Purpose:

- The shutoff and regulating valve is used to control regulated 15th stage air to the anti-ice spray bar for inlet cowl lip thermal anti-icing.

Location:

- The shutoff and regulating valve is found on the fan case at the 5:00 position.

Description and Operation:

- Shutoff and pressure regulating functions
- Electrically controlled - pneumatically actuated
- Has visual position indicator
- Has provisions for manual override

ANTI-ICE PRESSURE SWITCH

Purpose:

- The anti-ice pressure switch gives shutoff and regulating valve position disagreement and fault logic.

Location:

- The anti-ice pressure switch is found on the fan case at the 5:00 position.

Description and Operation:

- Normally open / pneumatically closed
- Senses pressure downstream of the shutoff and regulating valve

VISUAL OVERPRESSURE INDICATOR

Purpose:

- The visual overpressure indicator:
  - Shows overpressure sensed on the downstream side of the shutoff and regulating valves.
  - Indicates failure or degradation of pressure regulation.

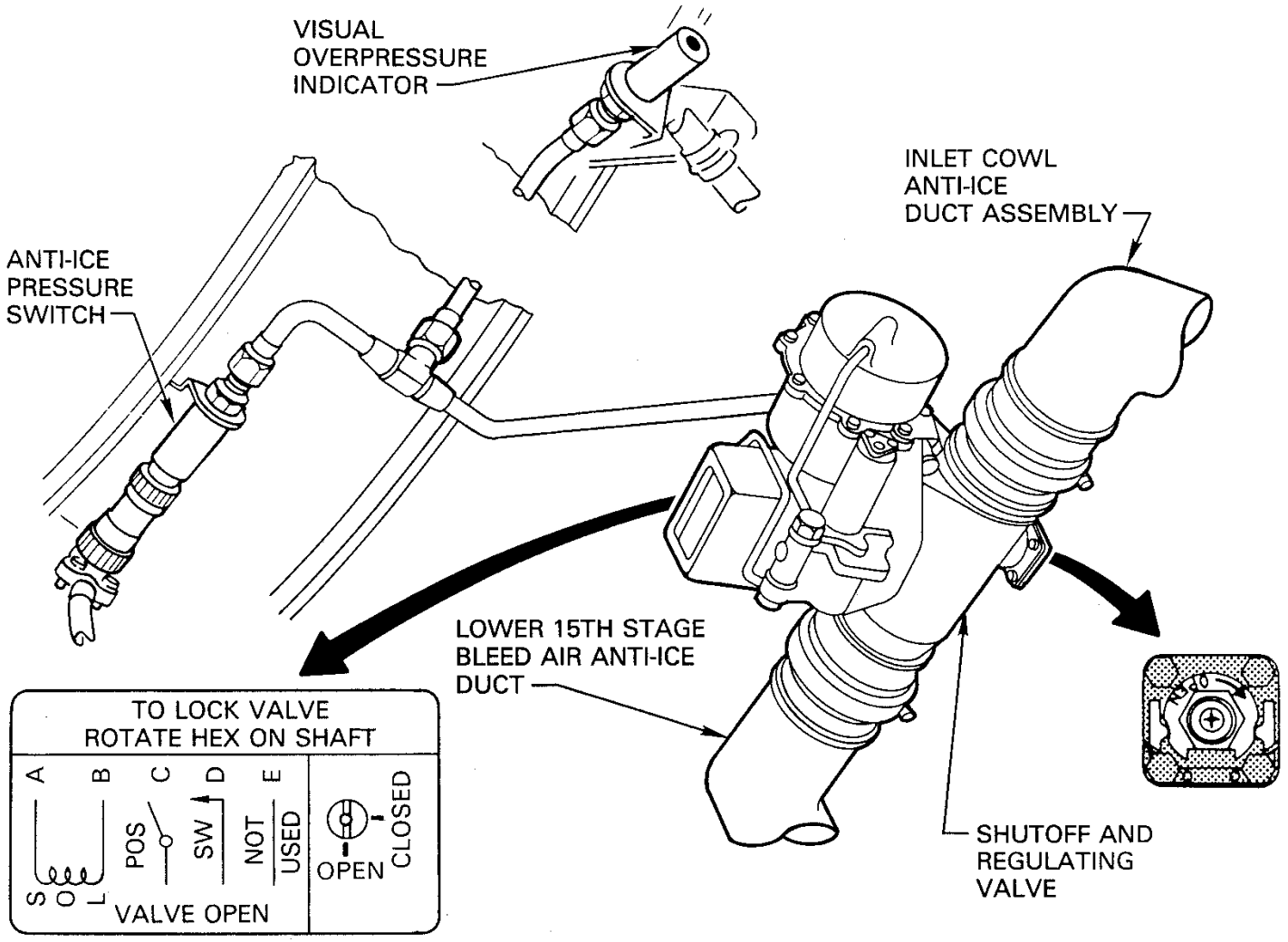
Location:

- The visual overpressure indicator is found on the fan case at the 5:00 position.

Description and Operation:

- Pop-out overpressure indicator - red button
- Senses pressure downstream of the shutoff and regulating valve
- Manual reset

Inlet Cowl Anti-Ice System Components



CT4118.19971009

CT4118

Anti-Ice Selection and Indication

INLET COWL - ANTI-ICE SWITCHES (2)

Purpose:

- The anti-ice switches permit anti-ice air to flow to the inlet cowl.

Location:

- The anti-ice switches are found on the cockpit overhead panel - forward left side.

Description and Operation:

- When pushed in, the inlet cowl anti-icing shutoff and regulating valve opens to supply hot high pressure compressor air to enter the inlet cowl.

INLET COWL - INDICATOR LIGHTS (2)

Purpose:

- The indicator lights indicate the inlet cowl anti-icing shutoff and regulating valve:
  - Has opened (ON).
  - Has failed closed or open (FAULT).

Location:

- The indicator light is part of the anti-ice switch found on the cockpit overhead panel - forward left side.

Description and Operation:

- When the system is turned ON, disagreement with selected position is normally shown by a fault light (amber) lit momentarily then extinguished. If the valve fails to go to a selected position, the fault light stays ON and the ECAM system is activated after 3 seconds.
- Lights are blue with normal operation.

ENGINE PRESSURE PROBES - PROBE HEAT PANEL

Purpose:

- The engine pressure probes on the probe heat panel indicate when the Mach probes (engine averaging pressure probes) and the PT2 / TT2 probe (PT2 probe) anti-icing systems circuits are failed.

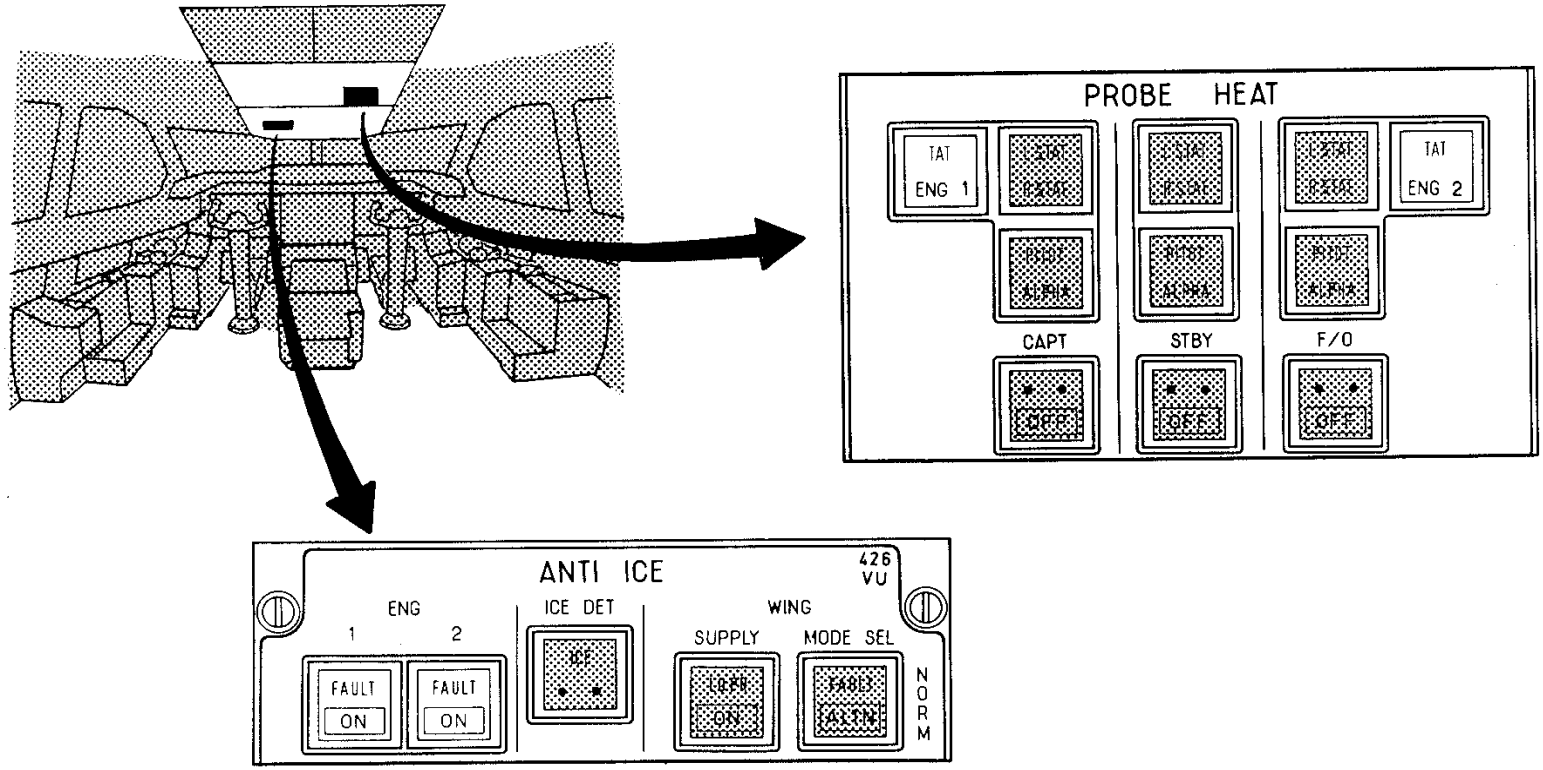
Location:

- The probe heat panel is found on the cockpit overhead panel - forward right side.

Description and Operation:

- Systems turned ON when the high pressure fuel shutoff valve is signaled open. ENG 1 or 2 system failure turns on amber fault light and activates ECAM system.
  - ***Warning:*** During static ground test of probe's anti-icing system, do not apply current for more than one minute.

Anti-Ice Selection and Indication



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CT3425

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THRUST REVERSER ACTUATION SYSTEM

Thrust Reverser System - General

Purpose:

- The thrust reverser system is used to safely reduce the length of the landing roll of the aircraft without any loss of directional control of the aircraft.
- **There are four actuation system operational modes:**
  - **Normal Deploy**
  - **Normal Stow**
  - **Manual Inhibit**
  - **Autostow**

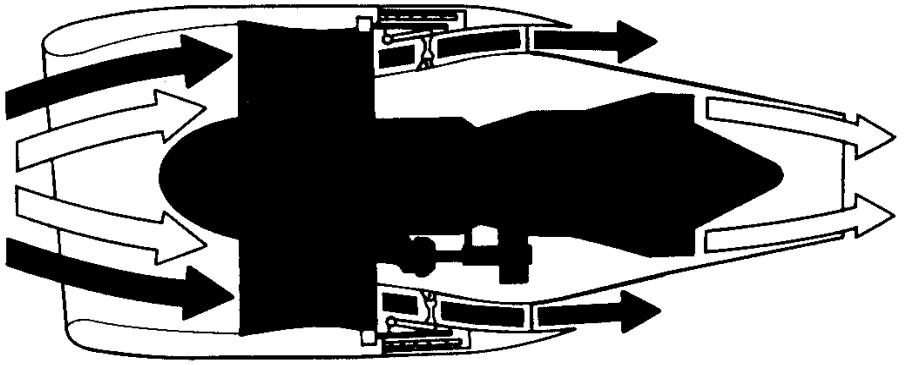
Components:

- Two position translating sleeves (stowed and deployed)
- Fan air blocker doors
- Cascade vane sections

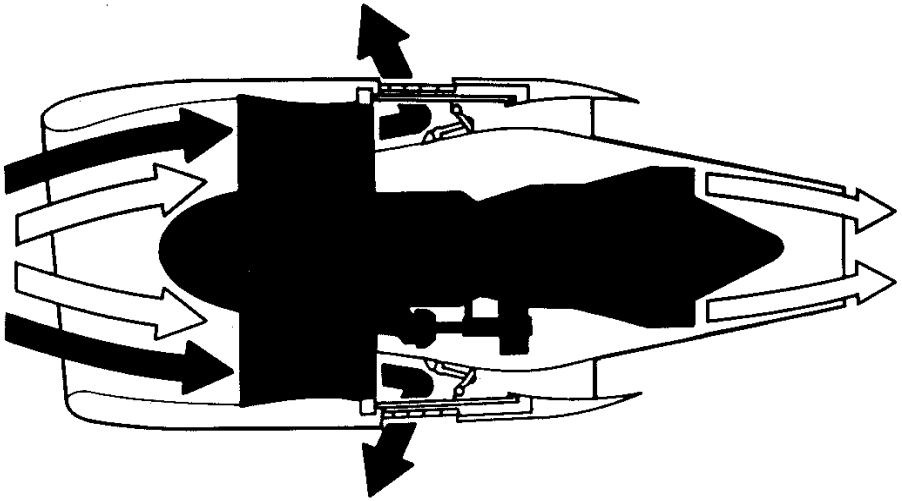
Description and Operation:

- Stowed*
  - The fan thrust reverser forms the passage for fan airflow for normal forward operation.
- Deployed*
  - The blocker doors cause the fan air to be directed outward and forward through the cascade vanes to reduce the aircraft's landing distance.

Thrust Reverser



STOWED



DEPLOYED

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CT4016

Thrust Reverser System - Major Assemblies

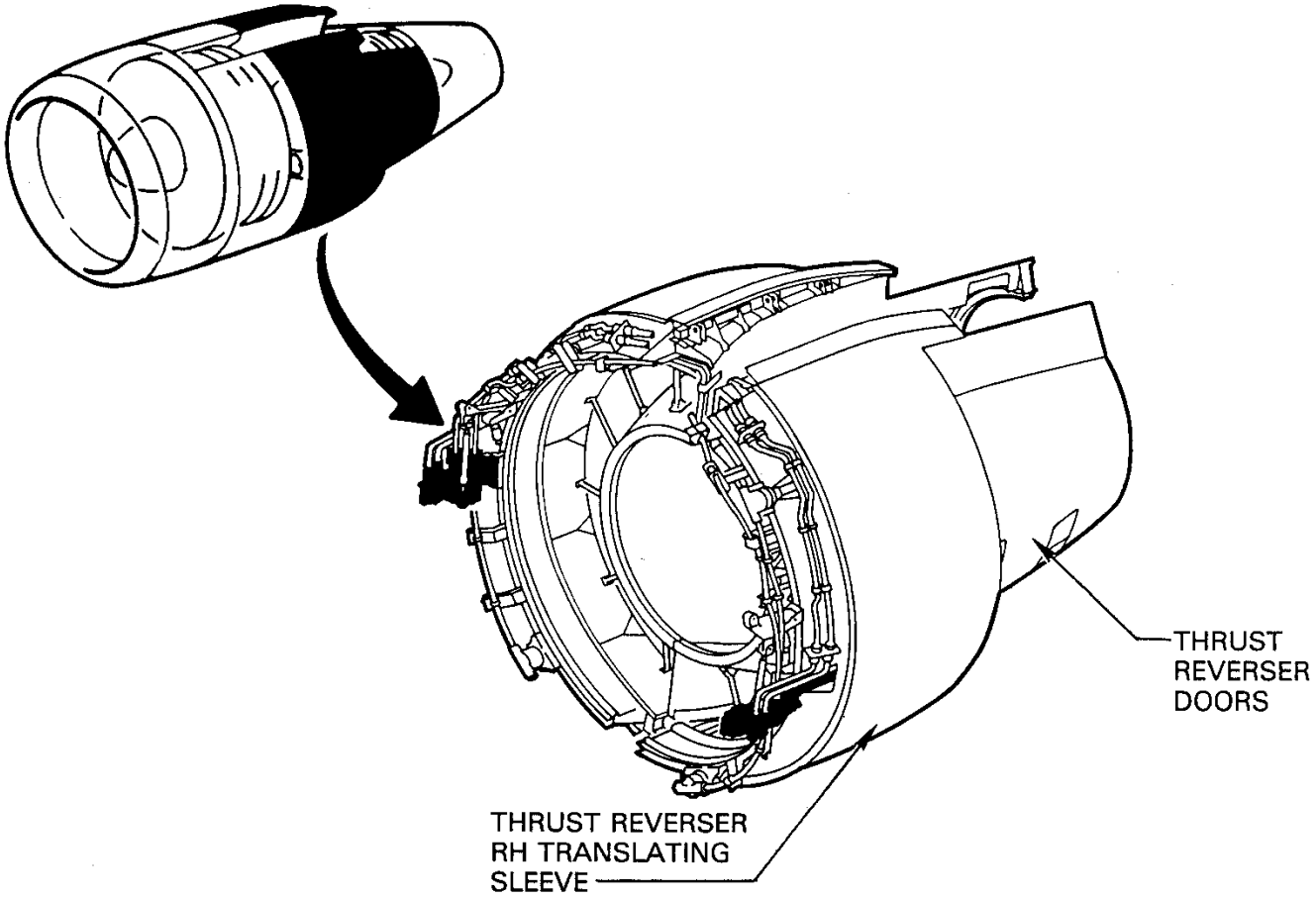
Thrust Reverser Doors

- The thrust reverser doors are hinged to the pylon and, when closed, mate with the V grooves on the engine fan case.

Translating Sleeves

- The translating sleeves are **slider-mounted** to the thrust reverser doors on **teflon-coated tracks** at the 6:00 and 12:00 positions.

Thrust Reverser Major Assemblies



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CT4119

Thrust Reverser Door - Forward Area

Master Actuators

- Master actuators are gimbal-mounted to the thrust reverser door bulkhead and attached to the translating sleeves.
  - The two master actuators are found on the thrust reverser doors at the 3:00 and 9:00 positions.

Slave Actuators

- The slave actuators are gimbal-mounted to the thrust reverser door bulkhead and attached to the translating sleeves.
  - The four slave actuators are found on the thrust reverser doors at the 2:00, 4:00, 8:00, and 10:00 positions.

Deploy Switches

- The two deploy switches are installed on the master actuator feedback rod bellcrank brackets at the 2:30 and 9:30 positions.

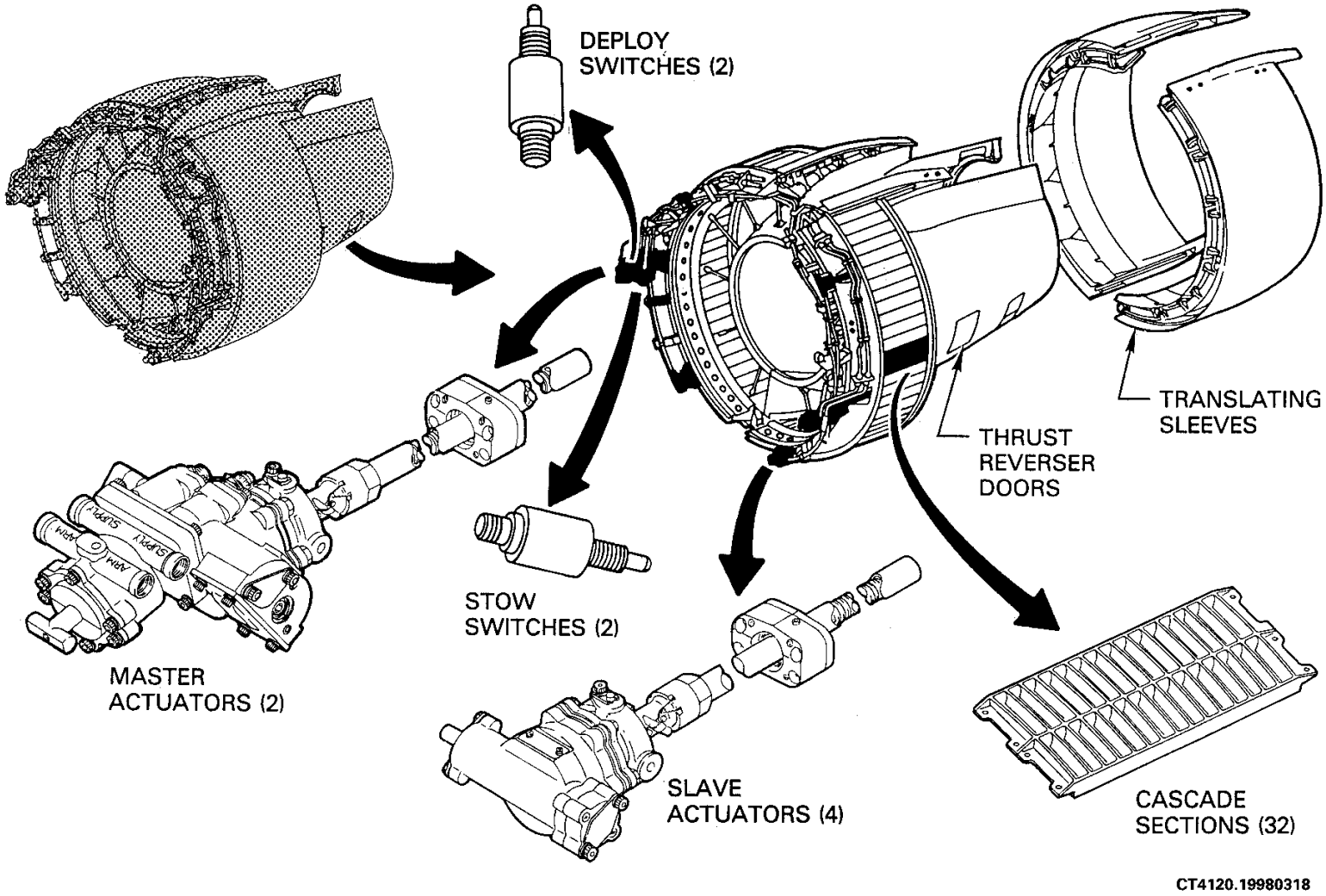
Stow Switches

- The two stow switches are mounted on the thrust reverser door bulkhead at the 3:00 and 9:00 positions.

Cascade Sections

- The cascade sections are mounted on the thrust reverser door.

Thrust Reverser (External View)



Thrust Reverser Door/Translating Sleeve - Internal

Blocker Doors and Blocker Door Links

- The blocker doors are hinged to the translating sleeve and attached to the thrust reverser door by blocker door links.

Forward and Aft Hold-open Rods

- The forward and aft hold-open rods are mounted to the thrust reverser door
- When holding the door open, one end attaches to the engine.
- Stored on the door

V-groove Blades

- Inner V-groove blade on the inner fan case portion of the thrust reverser door
- Outer V-groove blade on outer fan case portion of the thrust reverser door

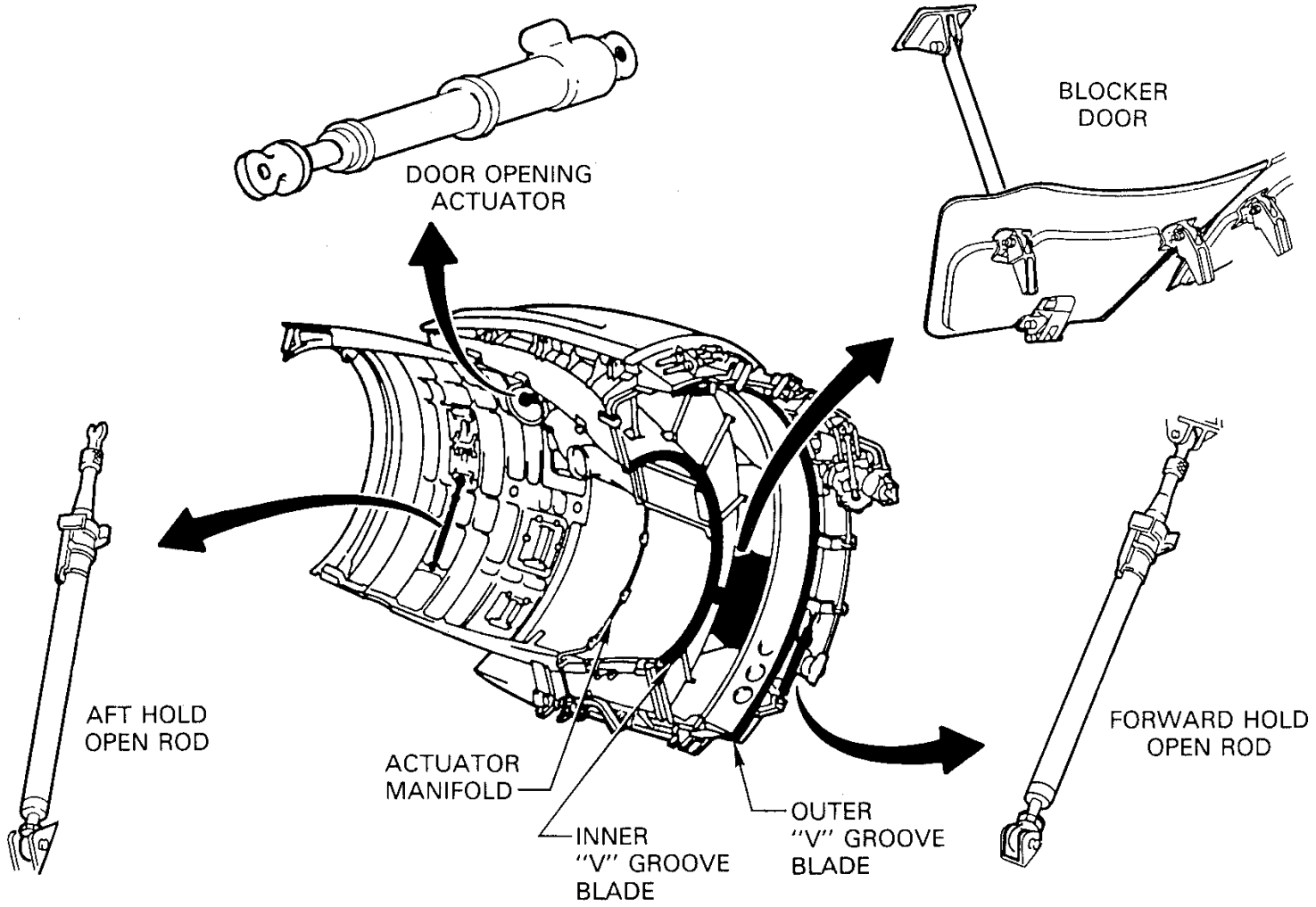
Door Opening Actuator

- The door opening actuator is mounted to the pylon and to the upper part of the thrust reverser door

Actuator Manifold

- The actuator manifold is mounted to the bifurcation duct

Thrust Reverser (Internal View)



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CT4121

Fan Case-Mounted Components

ENGINE - LEFT SIDE

Ground Valve

- The ground valve is located in the 15th stage duct at the 6:00 position.

Pressure Regulating and Shutoff Valve

- The pressure regulating and shutoff valve is mounted on the fan case at the 7:00 position.

Pneumatic Drive Unit (PDU)

- The PDU is mounted to the fan case at the 8:00 position.

Selector Valve

- The selector valve is mounted to the fan case at the 8:30 position.

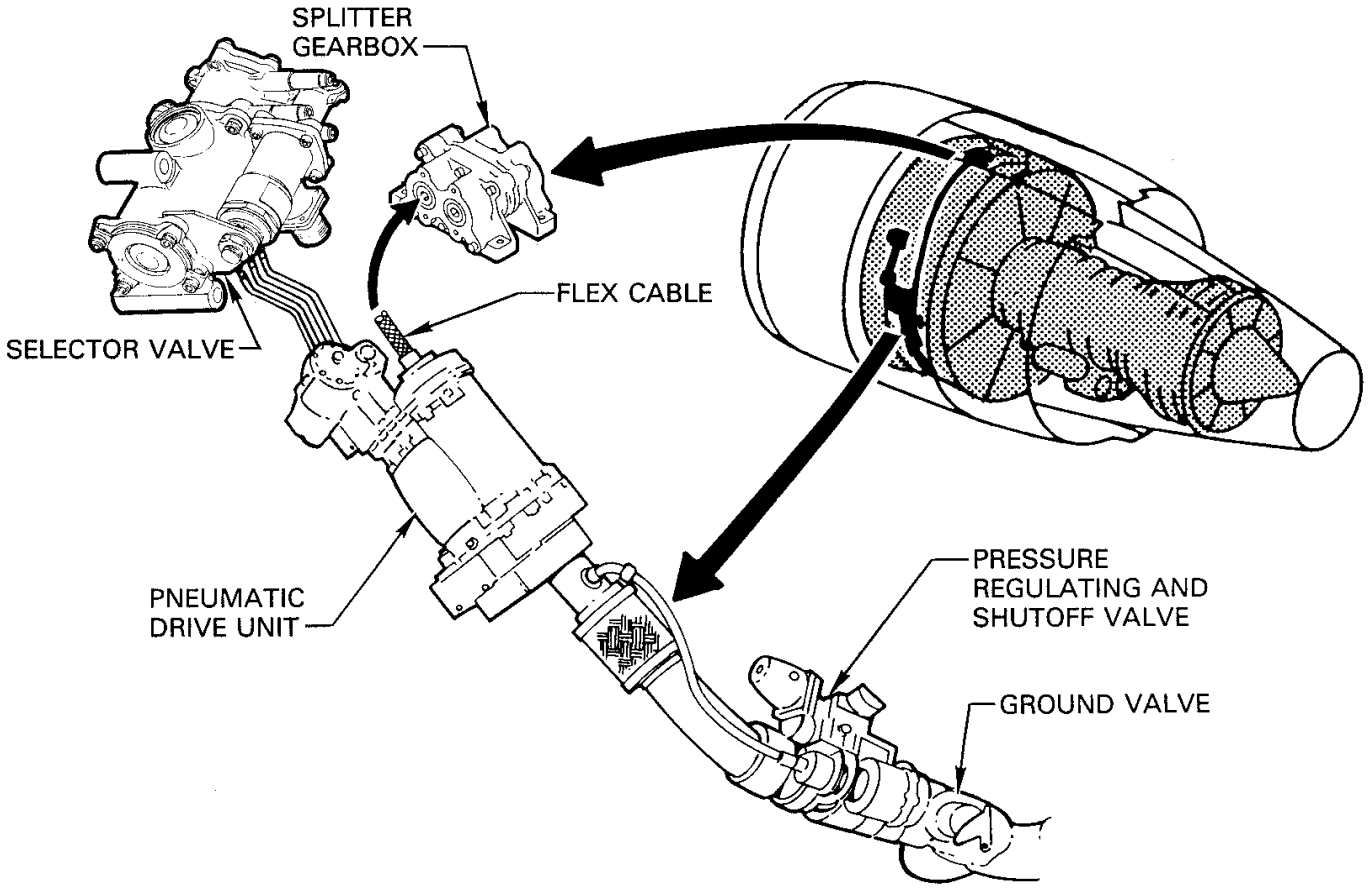
Flex Cable

- The flex cable is mounted to the PDU and connected to the splitter gearbox.

Splitter Gearbox

- The splitter gearbox is mounted to the fan case at the 12:00 position.

Fan Case-Mounted Components



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Thrust Reverser Doors/Translating Sleeves

THRUST REVERSER DOORS

Purpose:

- The thrust reverser doors form the fan discharge duct, permit access to the core engine components, and give load paths for cowl load sharing.

Location:

- The thrust reverser doors are hinged to the pylon and (when closed) have their V-grooves mate to the D and D1 flanges on the fan case.

Description and Operation:

- Held closed by a system of eight latches
- Have access doors for some core engine-mounted accessories
- Support the translating sleeves on tracks at the 6:00 and 12:00 positions
- Support the thrust reverser actuation components
- Support the cascade sections

TRANSLATING SLEEVES

Purpose:

- The translating sleeves actuate the blocker doors as the sleeves translate fore and aft.

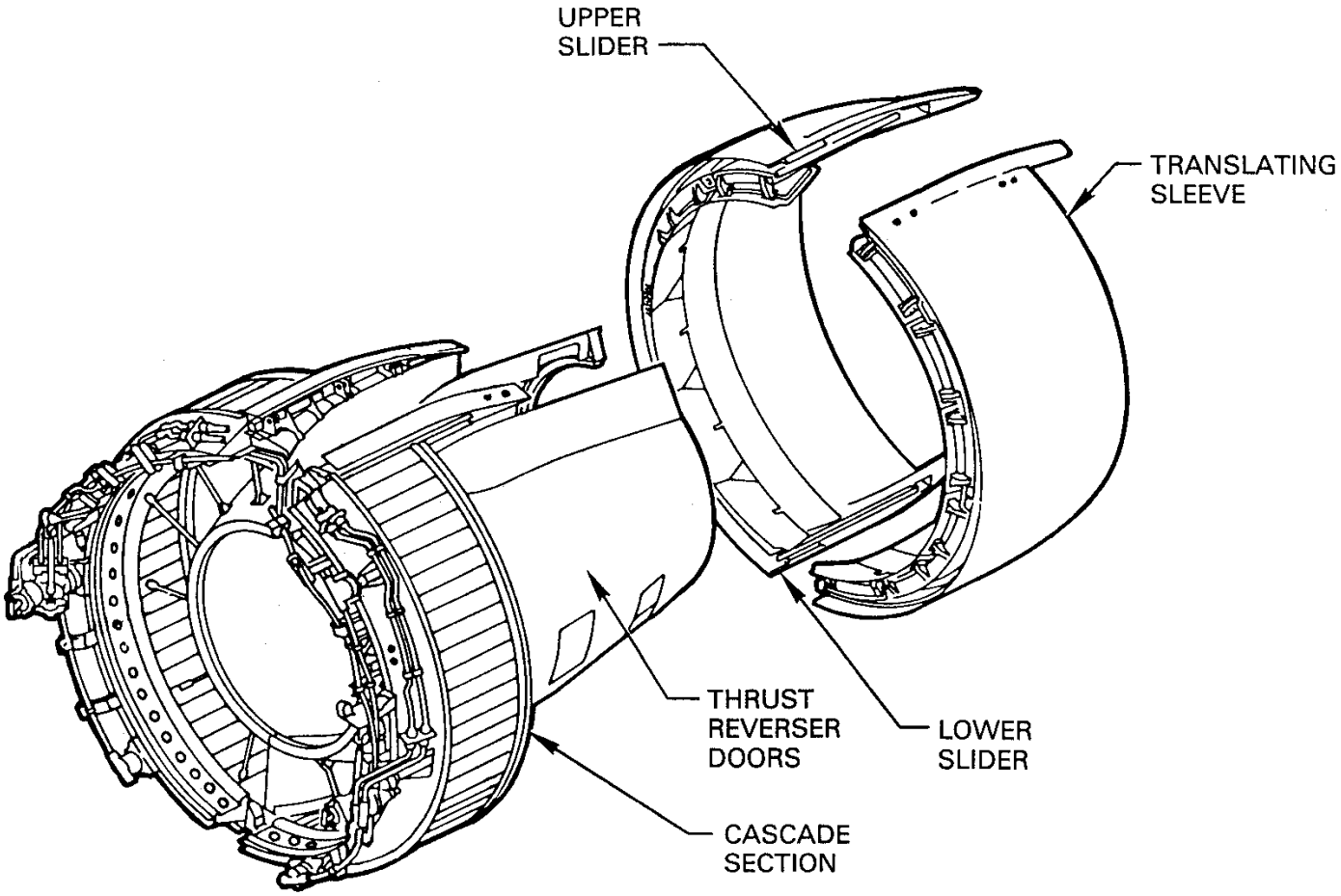
Location:

- The translating sleeves attach to the thrust reverser door tracks at the 6:00 and 12:00 positions.

Description and Operation:

- When the translating sleeves are driven aft (deployed) by the actuation system, blocker door links move the blocker doors into position and the cascade sections are exposed to redirect the fan air outward and forward.
- When the translating sleeves are driven forward (stowed) by the actuation system, the translating sleeves move the blocker doors (with the blocker door links) to permit the fan air to exit rearward at the fan nozzle.

Thrust Reverser Doors/Translating Sleeves



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CT4123

Thrust Reverser Cascades

Purpose:

- The thrust reverser cascades direct fan air outward and forward during reverser operation.

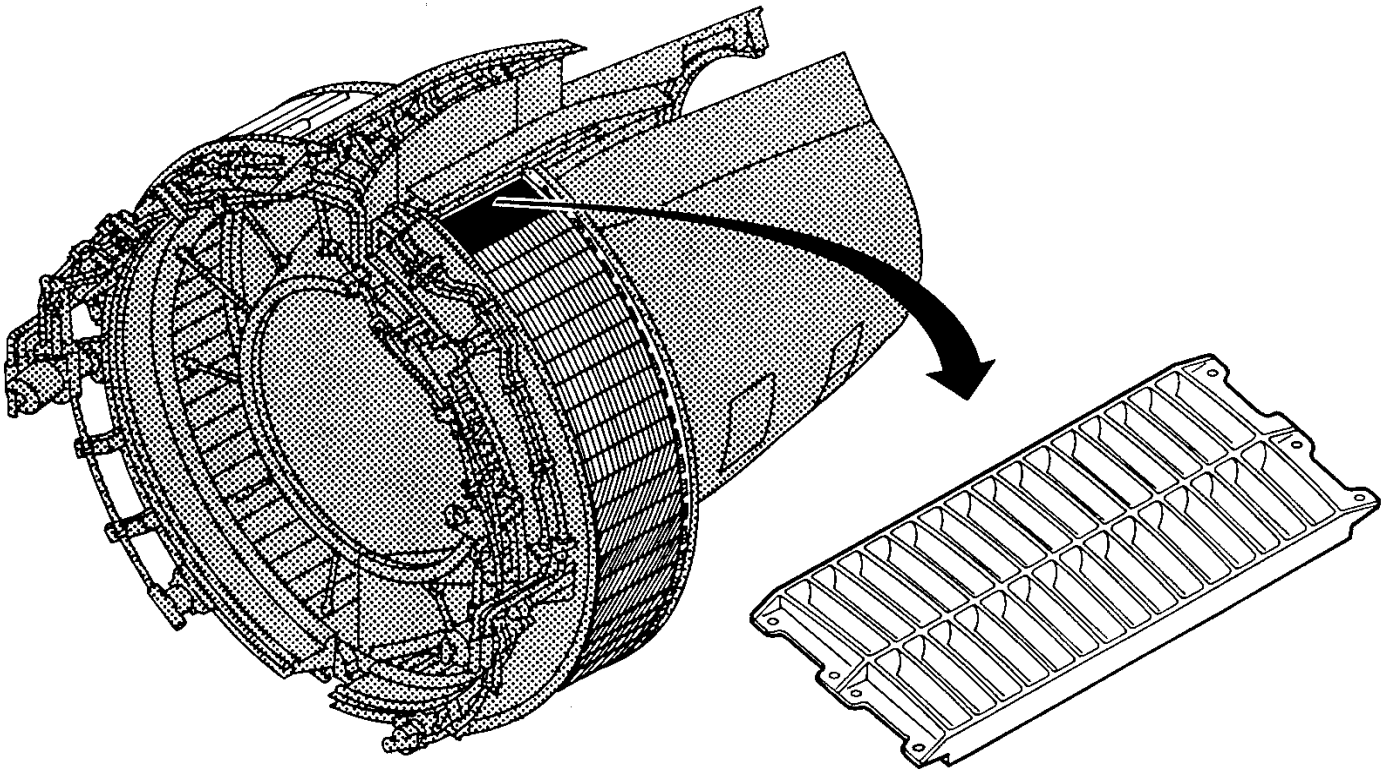
Location:

- There are thirty-two (32) cascade segments (16 per door) mounted between the forward and aft bulkhead.

Description and Operation:

- Normally covered by the translating sleeve, exposed during reverser operation
- Cascades are arranged by part number
  - **Caution:** Incorrect placement of cascades can cause damage to the engine or nacelle and affect engine performance.
- Cascades can be installed backwards
- Bolt torque is sequenced

Thrust Reverser Cascades



CT4124.19971009

CT4124

Ground Air Transfer Valve

Purpose:

- The ground air transfer valve gives a direct external air source to the regulating and shutoff valve for operating the thrust reverser with the engine shut down.

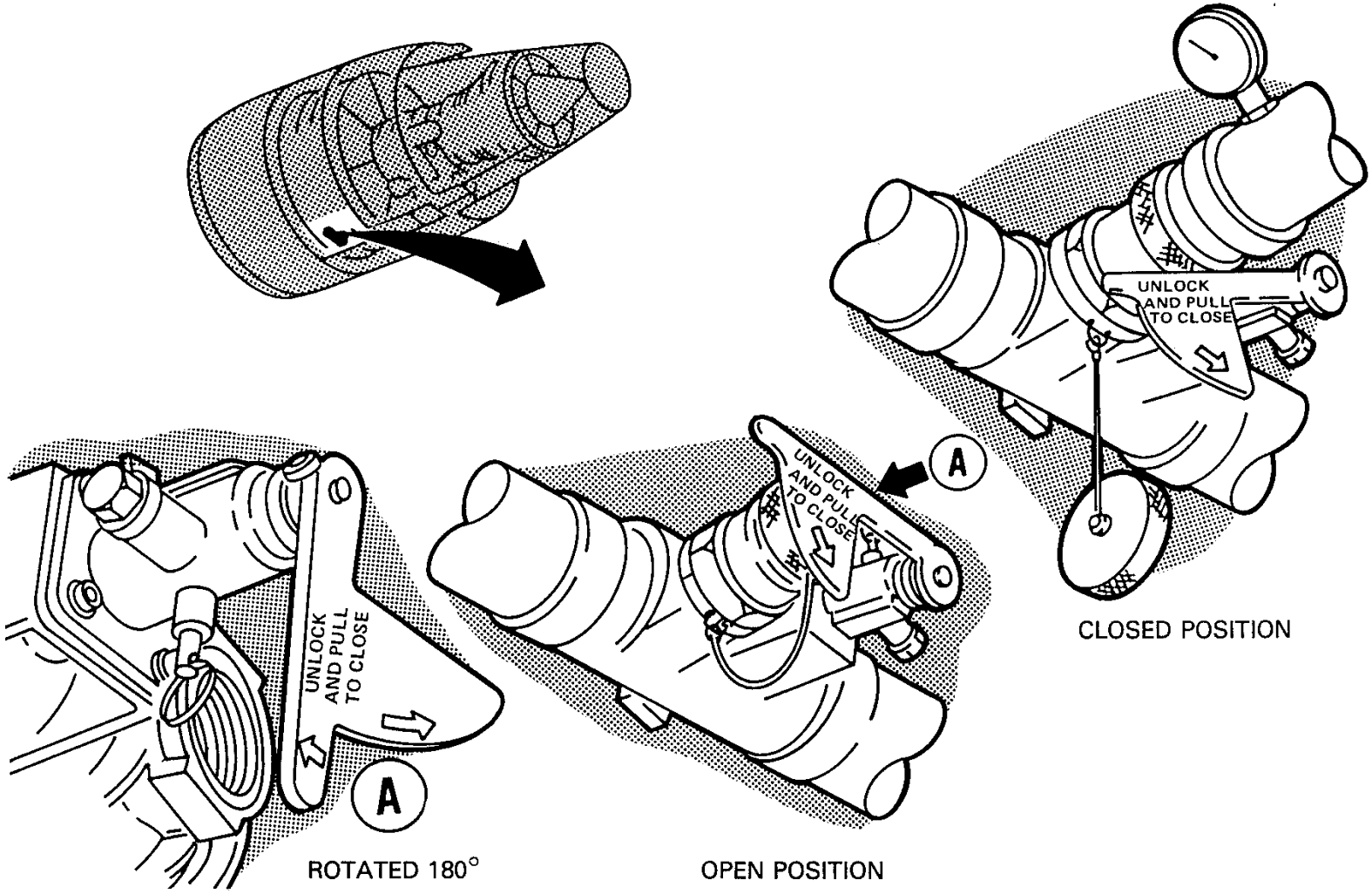
Location:

- The ground air transfer valve is found on the fan case at the 6:00 position.

Description and Operation:

- Valve is spring-loaded and locked open (flight mode)
- Valve directs 15th stage air to the thrust reverser system
- Manual override permits the introduction of external air used to actuate the thrust reverser with the engine shut down.

Ground Air Transfer Valve



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CT4125

Shutoff and Regulating Valve

Purpose:

- The shutoff and regulating valve regulates maximum air pressure and flow (45-55 psi) to the pneumatic drive unit.

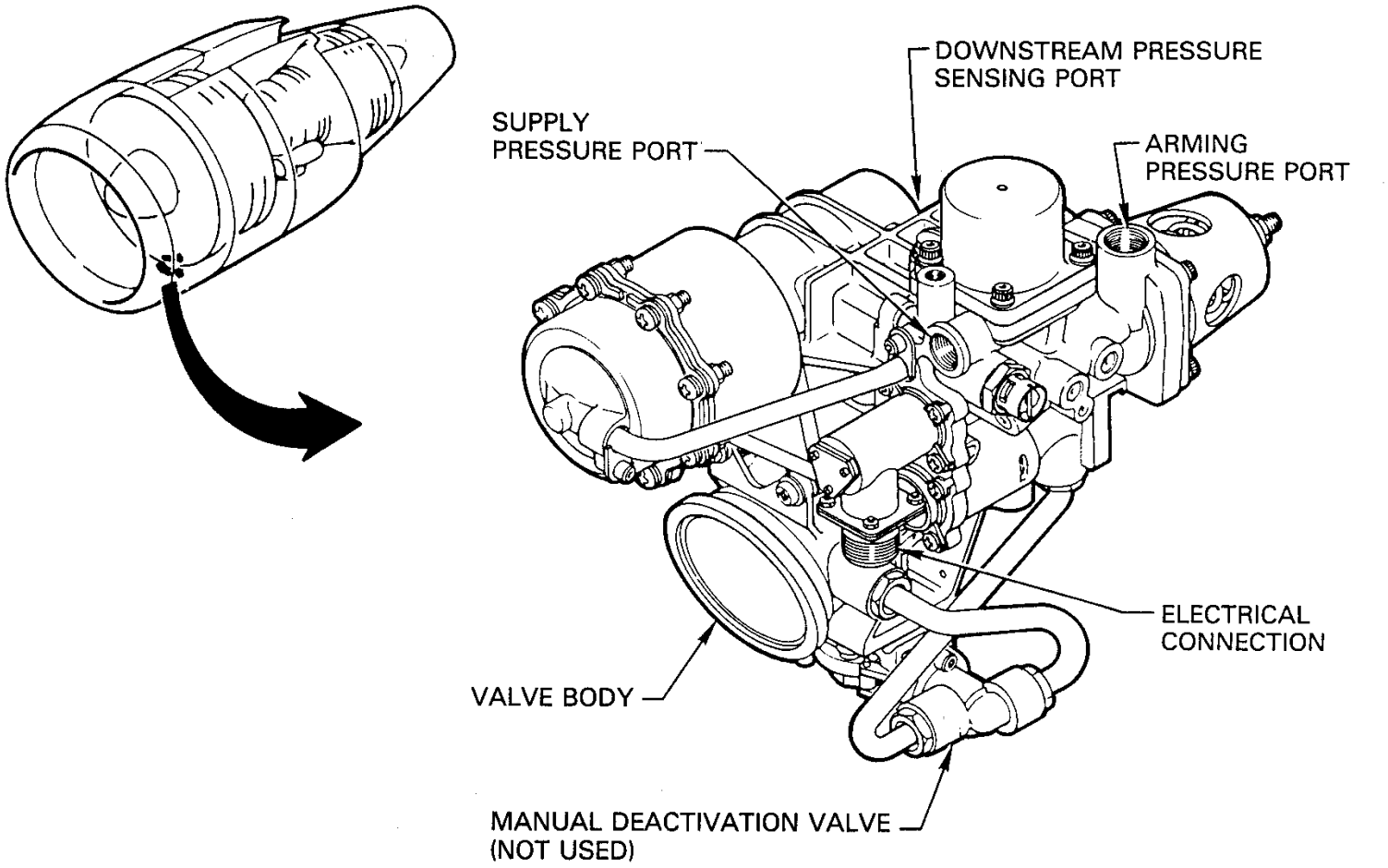
Location:

- The shutoff and regulating valve is found on the fan case at the 7:00 position.

Description and Operation:

- Valve is electrically controlled - pneumatically operated
- Inputs
  - 15th stage air
    - Inlet for operation of valve
    - Arming port from LH actuator to open valve
    - Sense port to feedback position for pressure regulation. (Sense is from PDU air inlet.)
  - Electrical
    - 28VDC to arming solenoid - deploy command from switch in throttle quadrant
  - Manual
    - Manual deactivation valve
- Outputs
  - Pneumatic
    - Supply port to unlock RH master actuator then LH master actuator and return to arming port
    - 15th stage air to PDU air motor for system actuation

Shutoff and Regulating Valve



CT4126.19971009

CT4126

Selector Valve

Purpose:

- The selector valve receives electrical signals for stow or deploy commands from the throttle quadrant switch packs and ports air to the PDU to establish the commanded direction of rotation for the requested position.

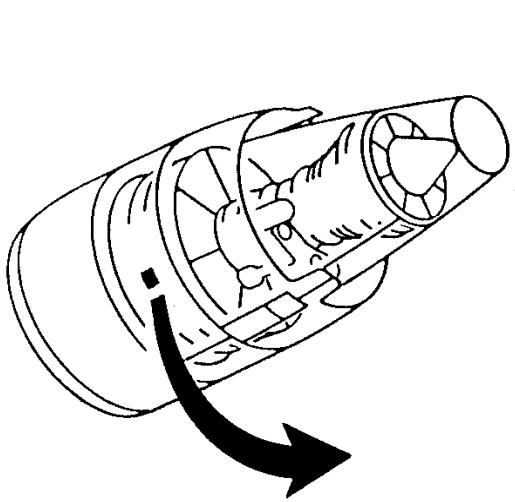
Location:

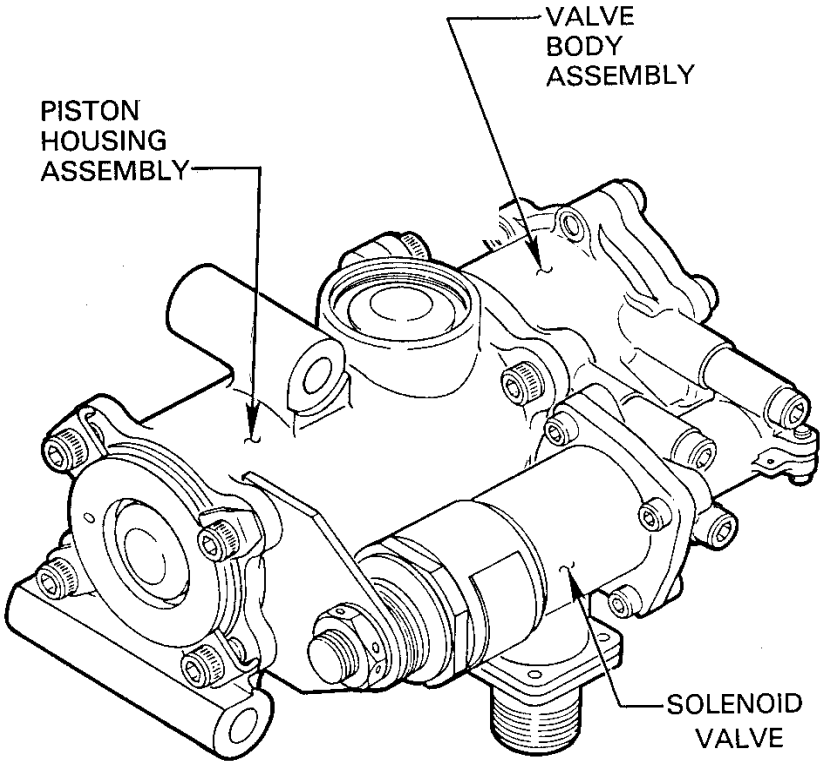
- The selector valve is found on the fan case at the 8:00 position.

Description and Operation:

- Two-position solenoid valve
  - Stow request
    - Solenoid A energized by switch pack on throttle quadrant
  - Deploy request
    - Solenoid B energized by switch pack on throttle quadrant
- Inputs
  - Regulated 15th stage air from the PDU
  - 28VDC from the throttle quadrant switch pack
    - Port A - Stow
    - Port B - Deploy
- Output
  - Regulated 15th stage air to deploy port or stow port on PDU

Selector Valve





CT3459.19971009

Pneumatic Drive Unit (PDU)

Purpose:

- The pneumatic drive unit (PDU) converts 15th stage air to mechanical drive which operates actuators that move the translating sleeves and blocker doors.

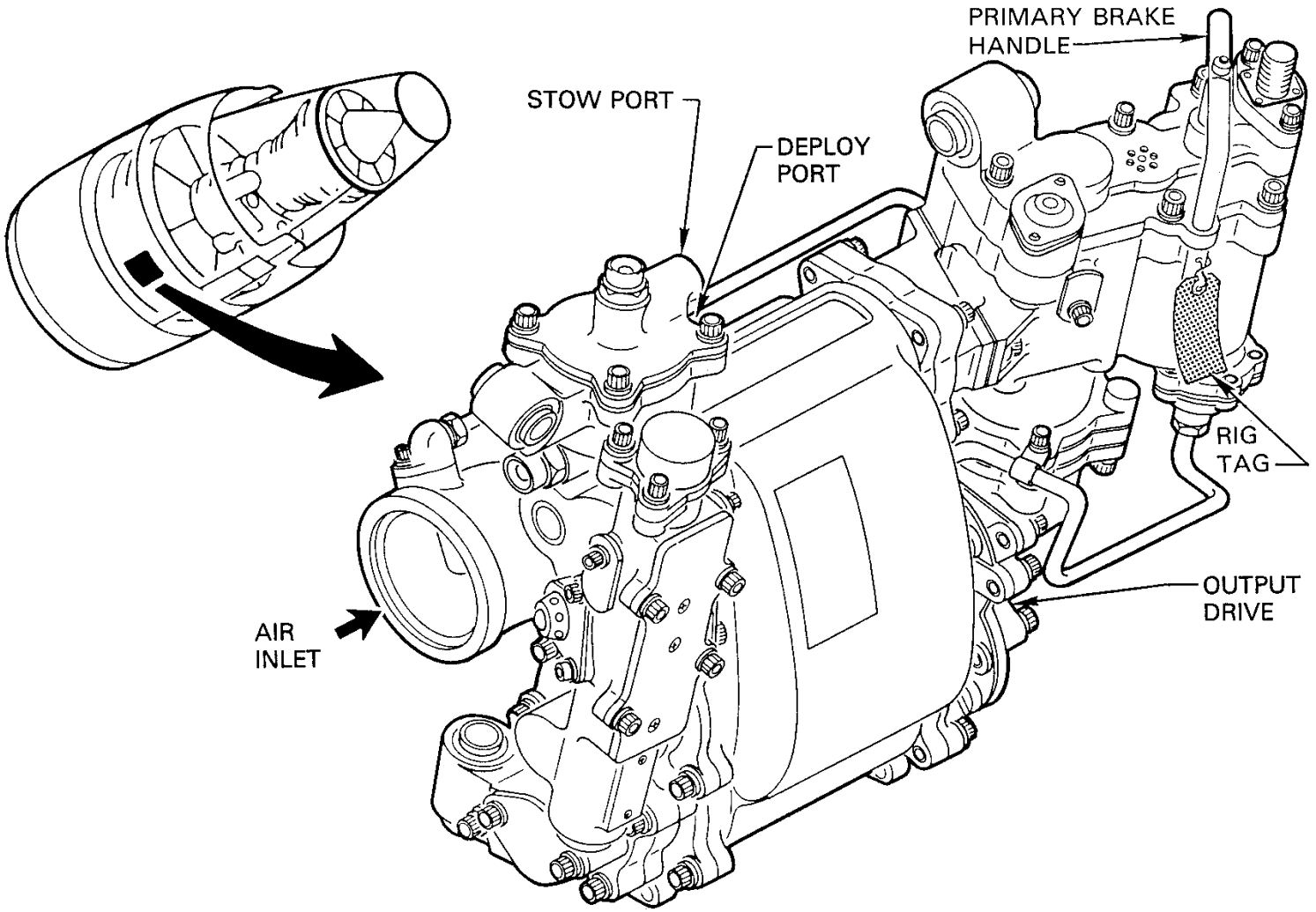
Location:

- The PDU is found on the fan case at the 7:30 position.

Description and Operation:

- Inputs
  - 28VDC to brake position switch
  - 15th stage air from shutoff and regulating valve to turn the air motor
  - 15th stage air from selector valve to stow or deploy port which positions the directional valve in the PDU
  - Manual brake release for rigging and manually driving the actuators
- Outputs
  - 28VDC from brake position switch to reverser unlock (REV UNLK) light during deploy cycle
  - Flexshaft to splitter gearbox for driving actuators
    - Note 1: New PDU is prerigged and will be lockwired, sealed, and has a rig tag attached
    - Note 2: Never manually drive the actuator system without pulling and securing the manual brake release or the PDU will be damaged.

Pneumatic Drive Unit



CT3457.19971009

CT3457

Splitter Gearbox

Purpose:

- The splitter gearbox is used to transfer power from the PDU to the master actuators.

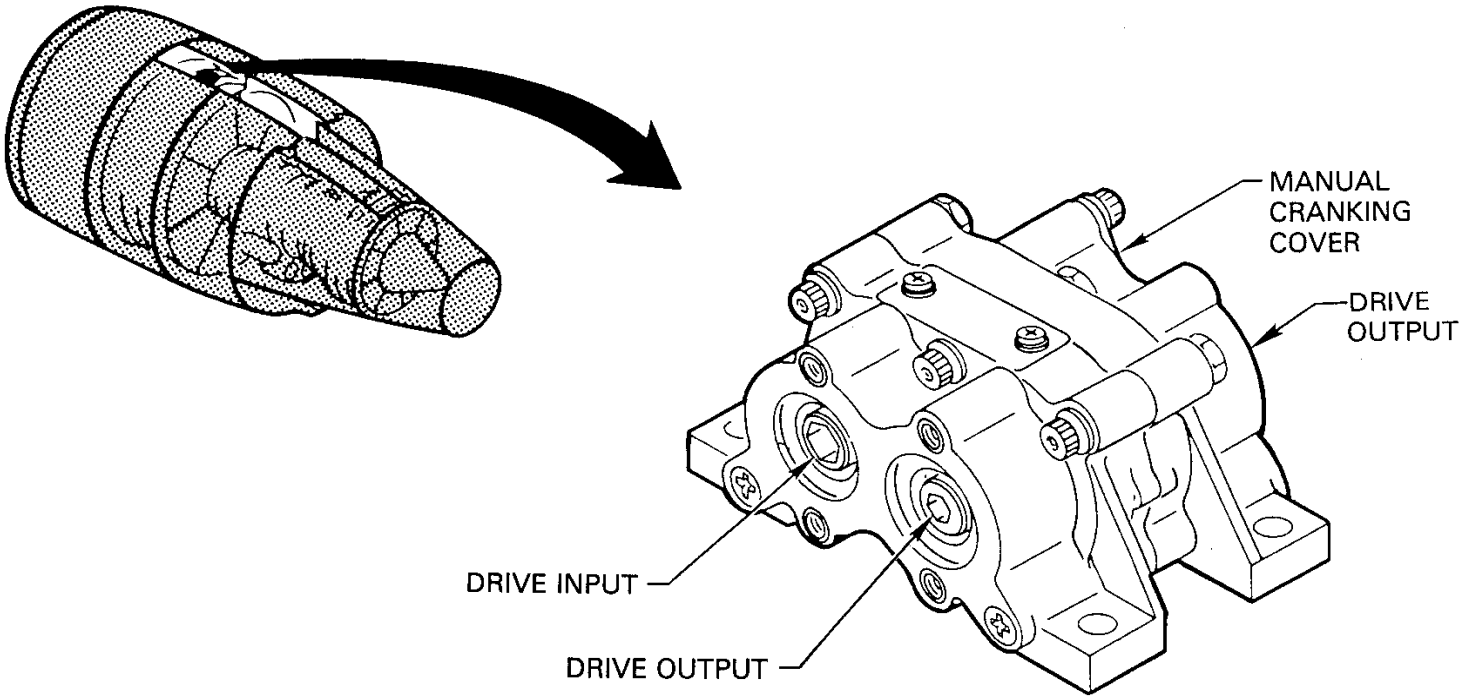
Location:

- The splitter gearbox is found on the fan case at the 12:00 position.

Description and Operation:

- 1:1 gear ratio power divider
- Inputs
  - Flex cable from the PDU
- Output
  - Flex cables to RH and LH master actuators
- Manual crank pad used to manually drive the thrust reverser system

Splitter Gearbox



CT4127.19971009

CT4127

Thrust Reverser Sleeve Master Actuator

Purpose:

- The master actuators are used to:
  - Convert low torque high speed input to linear motion for driving the translating sleeves.
  - Supply power to the slave actuators through interconnecting flex shafts.
  - Give displacement of throttle feedback rod for throttle lockout logic.

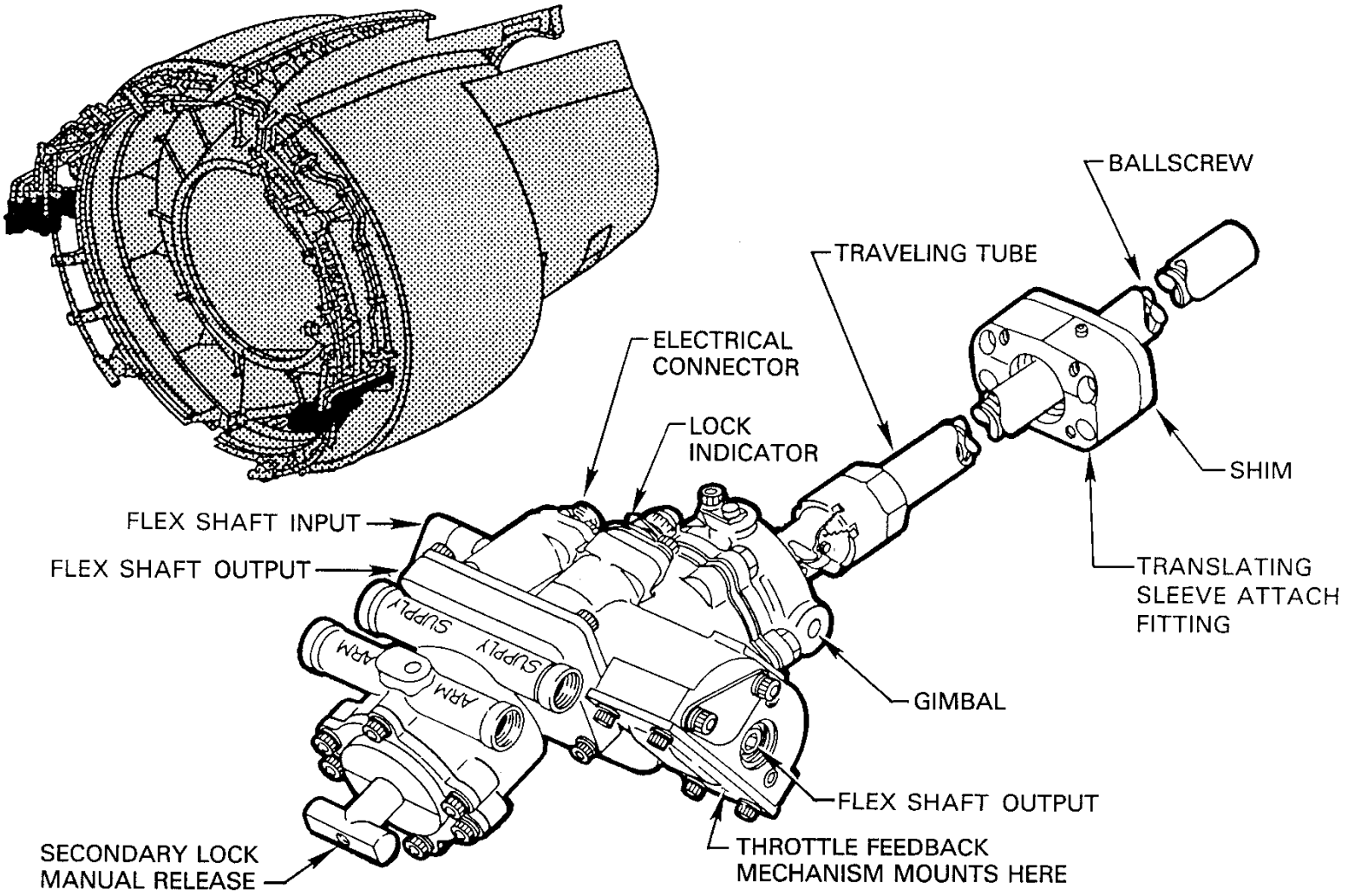
Location:

- The master actuators are gimbal mounted to the thrust reverser door bulkhead and attached to the translating sleeves at the 3:00 and 9:00 positions.

Description and Operation:

- Inputs
  - Arm port - 15th stage air to unlock actuator during the deploy sequence
  - Flex shaft from PDU to drive the traveling tube
  - Electrical power to unlock switch
  - Manual lock release for manual deploy of the system
- Outputs
  - Signal from secondary lock switch to reverser unlock light
  - Mechanical motion (actuator shaft) which drives the translating sleeve aft
  - Flex shaft drive to both slave actuators
  - Translating sleeve position feedback to throttle feedback system
  - Supply port - 15th stage air to unlock opposite master actuator during deploy sequence
- Manual crank pad used to manually drive the thrust reverser system

Thrust Reverser Sleeve Master Actuator



CT4128.19971009

CT4128

Thrust Reverser Sleeve Slave Actuator

Purpose:

- The slave actuators are used to convert rotary motion to linear motion for driving the translating sleeves.

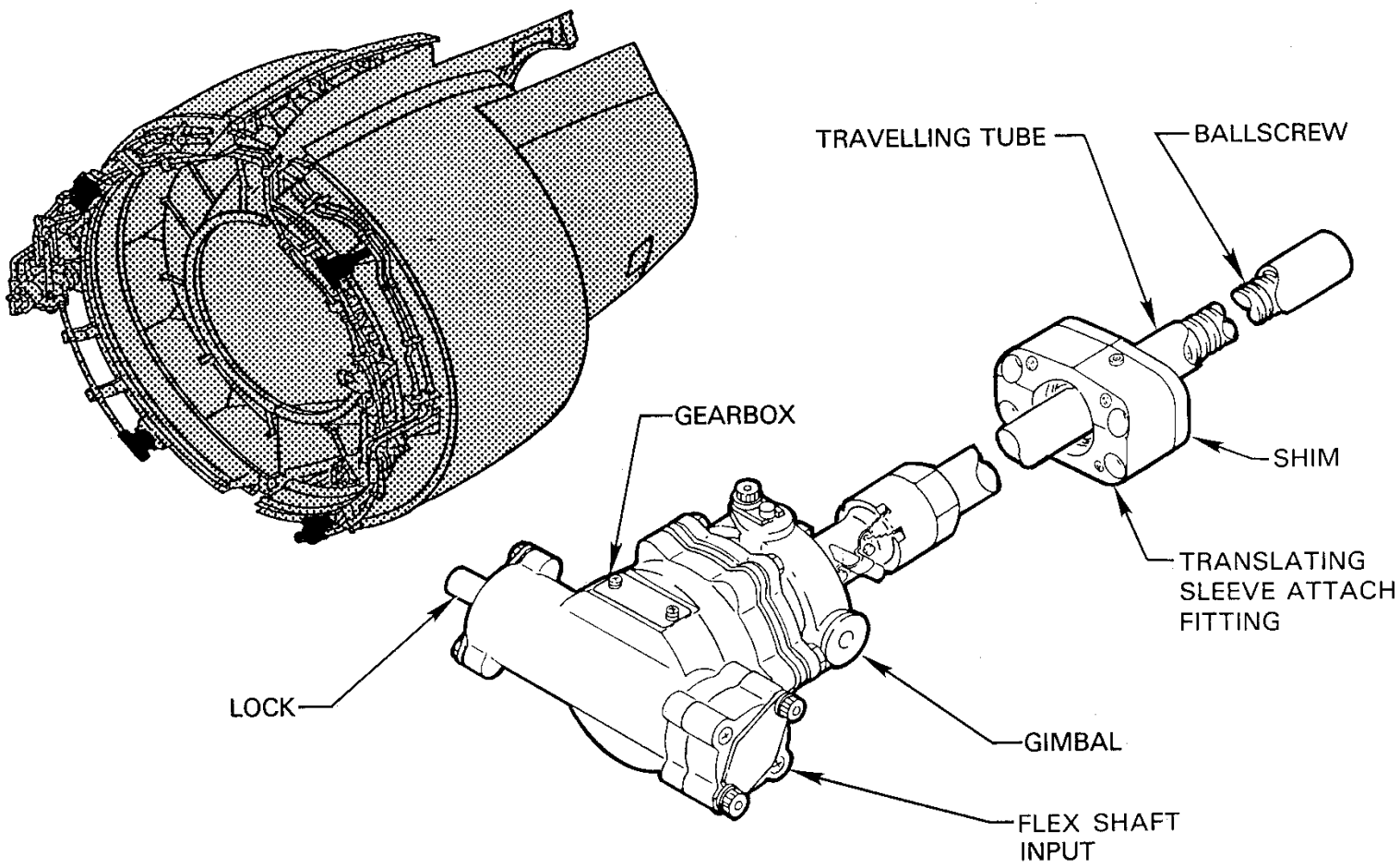
Location:

- The slave actuators are gimbal mounted to the thrust reverser door bulkhead and attached to the translating sleeves at the 2:00, 4:00, 8:00, and 10:00 positions.

Description and Operation:

- Input
  - Mechanical drive flex shafts from master actuators
- Output
  - Linear mechanical drive to move translating sleeves
- Uses a mechanical lock to deactivate the system

Thrust Reverser Sleeve Slave Actuator



CT3312.19971009

CT3312

Thrust Reverser Wiring And Switches

FORWARD J BOXES

Purpose:

- The forward J boxes are junction boxes for the wiring harness.

Location:

- The forward J boxes are pylon-mounted (one per door).

Description and Operation:

- Give quick connect / disconnect points for the thrust reverser electrical harness

DEPLOY SWITCHES

Purpose:

- Deploy switches signal when the thrust reverser is deployed.

Location:

- Installed on the master actuator feedback rod bellcrank brackets (one per door) at the 2:30 and 9:30 positions.

Description and Operation:

- Plunger-type switch activated by throttle feedback rod bellcrank
- Rigging required
- Gives signal to REV and REV UNLK lights
- When thrust reverser is deployed, REV UNLK light logic is canceled
- 28VDC output

STOW SWITCHES

Purpose:

- The stow switches signal when the thrust reverser is stowed or deployed.

Location:

- The stow switches are mounted on the thrust reverser door bulkheads (one per door).

Description and Operation:

- RH switch
  - Gives 28VDC signal to REV UNLK light when translating sleeve is not fully stowed - rigging required
- LH switch
  - De-energizes idle select solenoid for approach idle during reverser operation
  - If reverser opens in flight, either the RH or LH switch will give a signal to the auto restow circuit which drives the translating sleeve closed

MASTER ACTUATOR ELECTRICAL CONNECTORS

Purpose:

- The master actuator electrical connectors supply signals to the REV UNLK light when the secondary locks in the master actuators unlock.

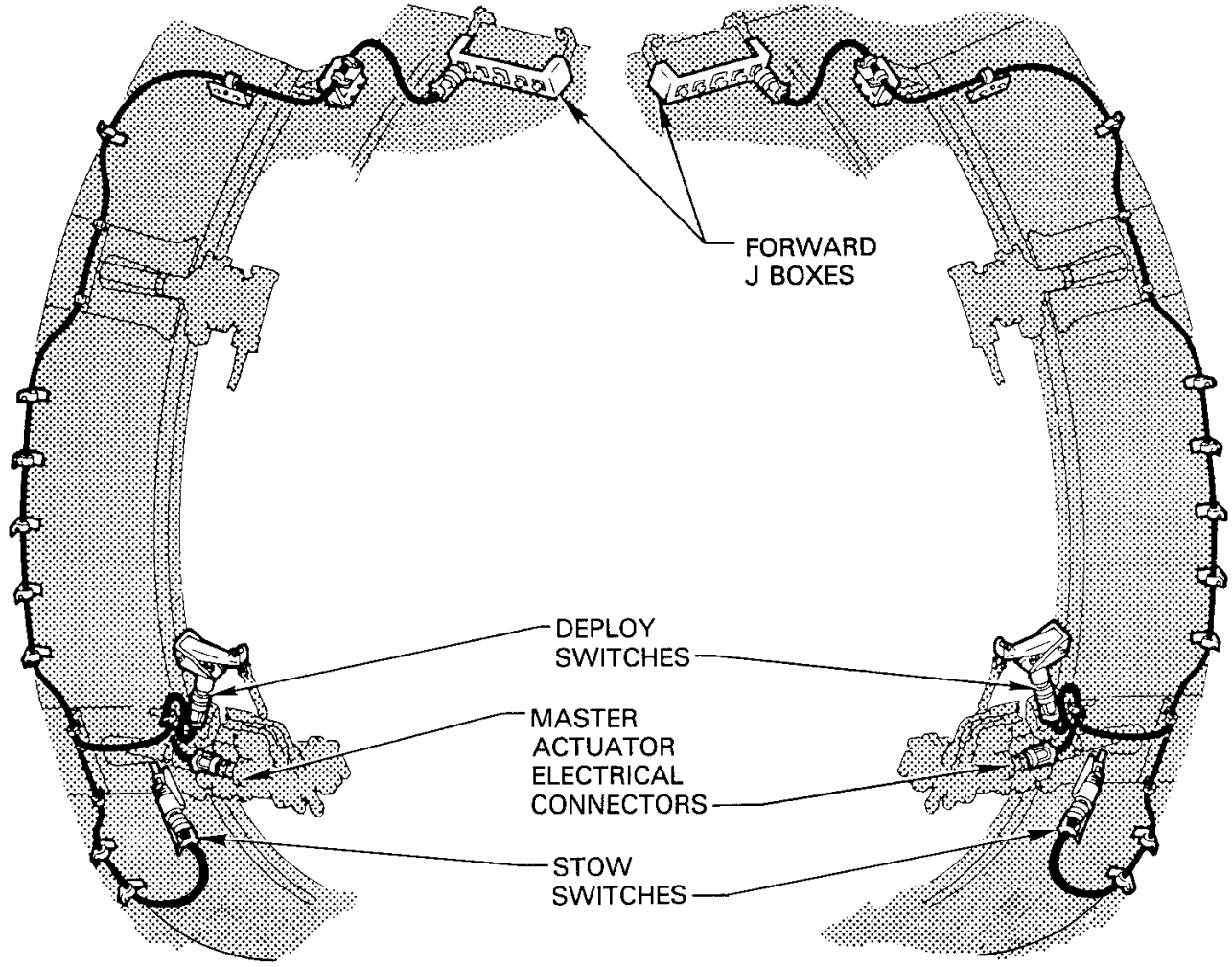
Location:

- The master actuator electrical connectors are found inside the master actuators.

Description and Operation:

- When secondary lock unlocks, signal is sent to the REV UNLK light
- No rigging required
  - Brake ON - switch open
  - Brake OFF - switch closed

Thrust Reverser Wiring And Switches



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CT4129

Thrust Reverser Pneumatic Sensor Lines

Purpose:

- The thrust reverser pneumatic sensor lines are used to
  - Send pneumatic signal / operating pressures to the thrust reverser master actuator secondary locks.
  - Give pneumatic feedback signals from master actuator secondary locks to the shutoff and regulating valve

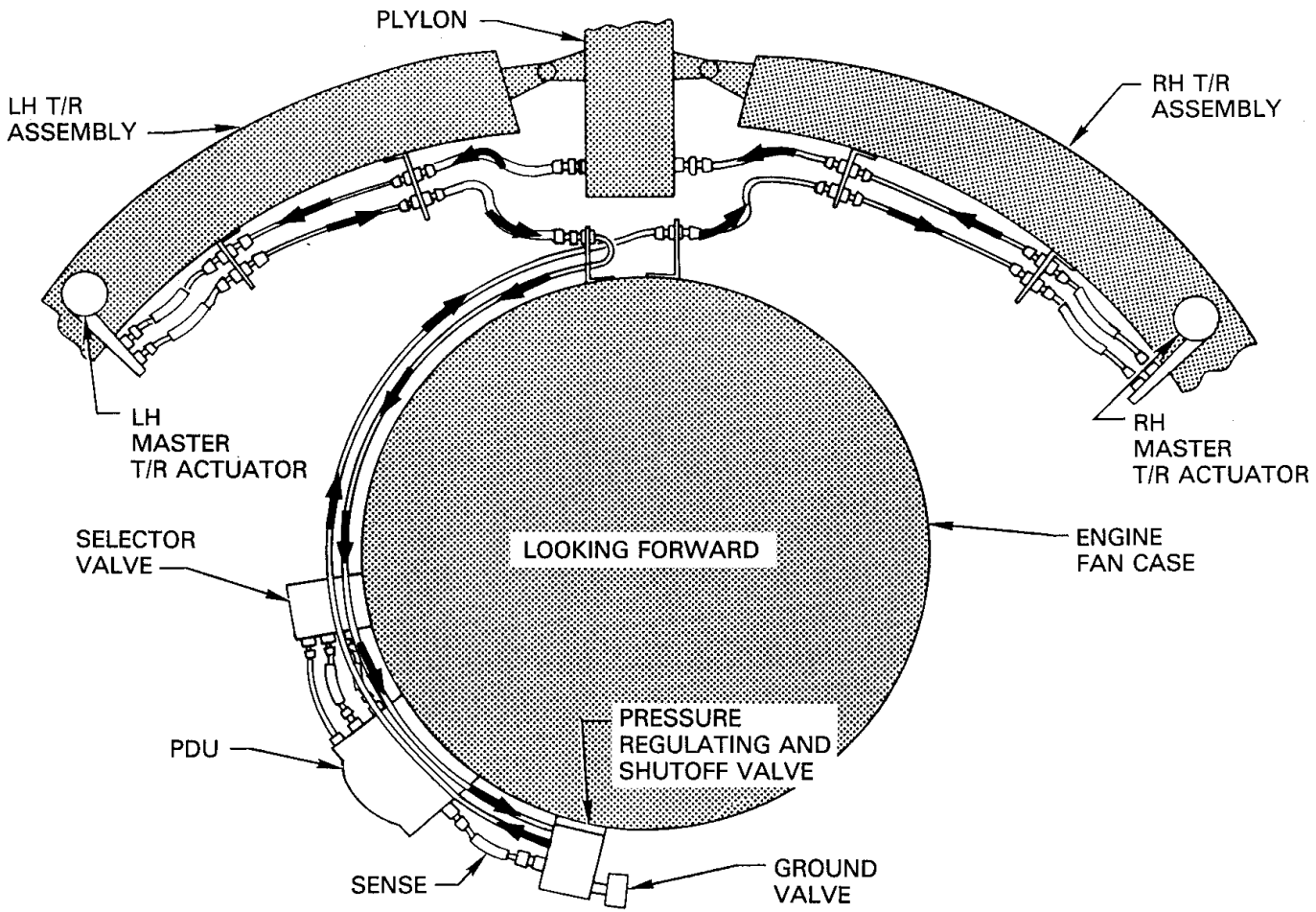
Location:

- The thrust reverser pneumatic sensor lines are attached to thrust reverser components and secured to the thrust reverser doors and pylon.

Description and Operation:

- Sequence of signal pressure operation
  - 15th stage air from the pressure regulating and shutoff valve unlocks the RH master actuator
  - Signal pressure continues to unlock the LH master actuator
  - From LH master actuator, signal returns to open the pressure regulating and shutoff valve which will then direct regulated 15th stage air to the PDU

Thrust Reverser Pneumatic Sensor Lines



Engine Control Linkage

Purpose:

- The engine control linkage gives thrust reverser position feedback to the aircraft throttle control system to prevent application of engine power above idle until the thrust reverser sleeves reach the 75% deploy position.

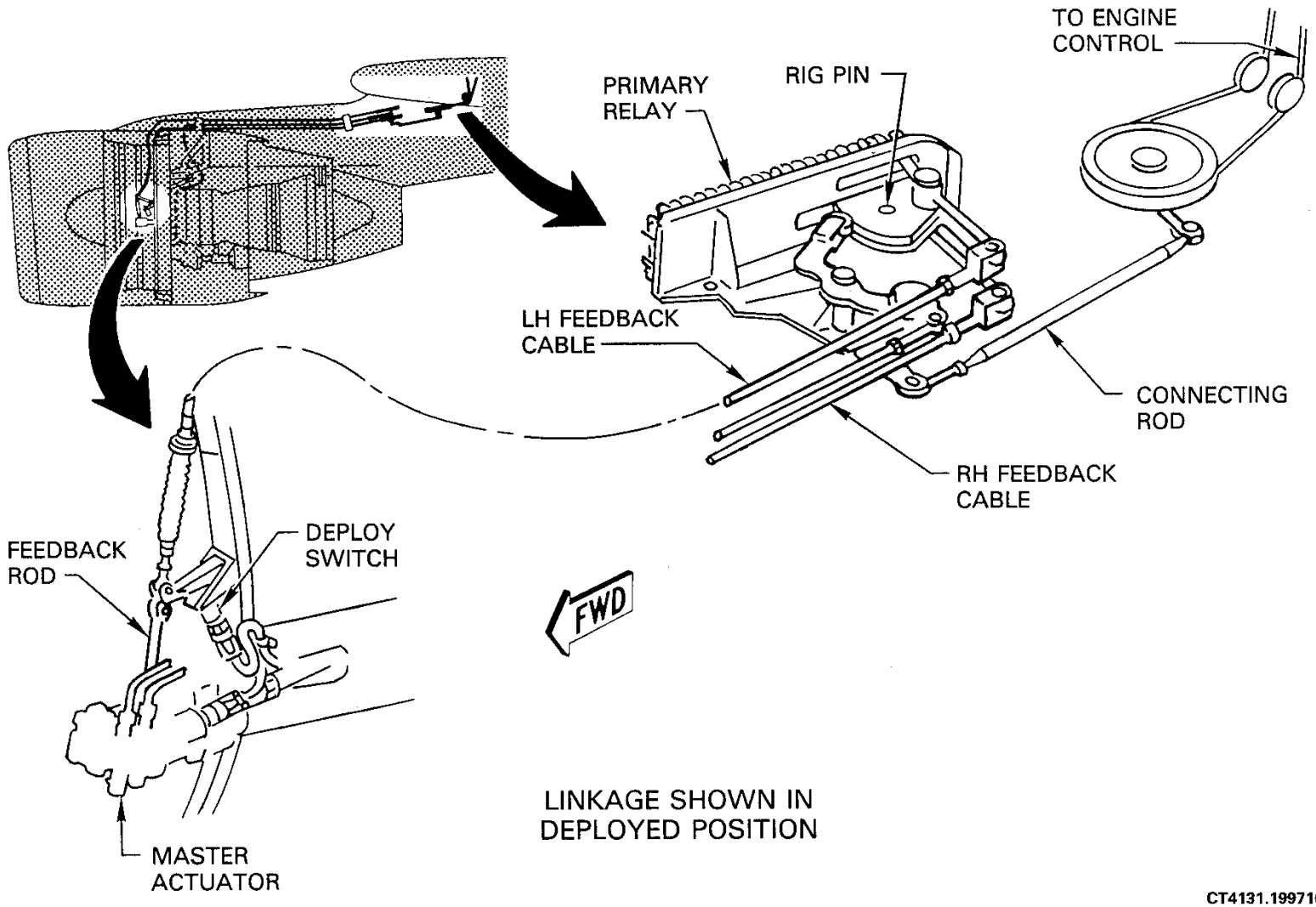
Location:

- The engine control linkage feedback rods are attached to the master actuators on one end and to the feedback cables at the other end.
- The engine control linkage feedback cables are attached to the throttle interlock control box.

Description and Operation:

- As the reverser translates through stow and deploy, each master actuator drives a feedback rod in a direction relating to translating sleeve travel.
- The feedback rods give mechanical feedback to the feedback cables. These feedbacks are used by the throttle interlock control box to:
  - Prevent engine power from exceeding idle conditions until the translating sleeves have reached the 75% deploy position.
  - Prevent canceling a deploy or stow request until the system has completely traveled in either direction.

Engine Control Linkage



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CT4131

Thrust Reverser Control And Indicator Lights

THRUST REVERSER CONTROL LEVERS

Purpose:

- The thrust reverser control levers are positioned to select the stow or deploy mode for thrust reverser operation.

Location:

- The thrust reverser control levers are found on the flight deck, control pedestal.

Description and Operation:

- Manually controlled
- Connected to the throttle gearbox by push-pull cables and rods
- Positions switches in throttle quadrant to give command (stow or deploy) signals

INDICATOR LIGHTS

Purpose:

- Indicator lights are used to give flight deck indication of thrust reverser status

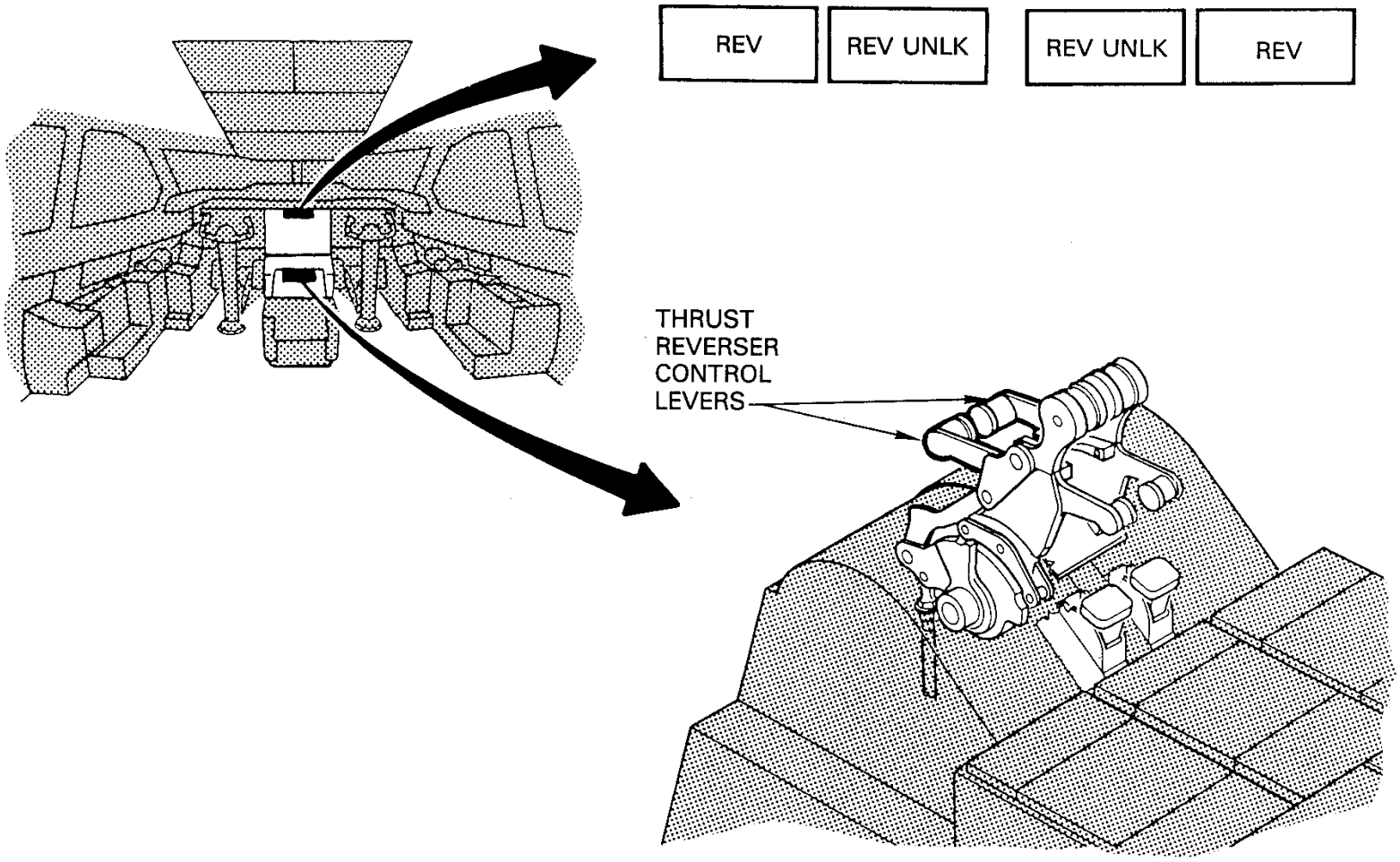
Location:

- The indicator lights are found on the flight deck, center panel.

Description and Operation:

- Reverser unlock light (REV UNLK)
  - Normally OFF
  - Illuminates amber when the thrust reverser is not locked in the stowed position
  - Controlled by:
    - RH stow switch
    - Secondary lock switches in master actuators
    - PDU brake switch
- Reverser light (REV)
  - Normally OFF
  - Illuminates green when the thrust reverser is deployed 94% or more of its travel
  - Controlled by deploy switches

Thrust Reverser Control And Indicator Lights



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